

METALLURGIA

THE BRITISH JOURNAL OF METALS.
INCORPORATING "THE METALLURGICAL ENGINEER".

JULY, 1936.

VOL. XIV., No. 81.

The Preparation of Metal Specimens for the Microscope

By R. C. STOCKTON

When investigating the structure of metals by means of the microscope it is necessary to exercise care in the selection and preparation of specimens in order that instructive micrographs can be obtained which will give reliable information regarding their structures. In this article some simple precautions are discussed.

THE preparation of metal surfaces for microscopic examination is by no means uniform in practice, and to this fact is due the writer's efforts herein to suggest methods whereby entirely satisfactory and consistent results may be obtained without undue wastage of time. Indifferent polishing will, at the least, promote unattractive micrographs, and may even lead to misleading interpretation of the micro-structures. A few simple precautions are all that is necessary, but their observance makes a profound difference to the final result with the attendant satisfaction inseparable from a task well done.

Shape of Specimens

The shape of the specimen, assuming that it is one which does not require special mounting for polishing, should be such that it will have inclination to rock when being polished. This is of first importance, as an absolutely flat surface is necessary on the finished piece, in order to obtain sharp focus. To effect this, the height should be considerably less than the lesser superficial dimension with rectangular specimens and not greater than the radius with round ones. Normally specimens are sawn off, but when a hard, brittle specimen has to be taken it is usually broken off and an approximate "flat" ground on it on a wet grind-stone. The first true polishing operation is done by rubbing the specimen face downwards on a flat file, the pressure applied varying with the nature of the metal. The method of holding the specimen is important. It should be gripped with the index finger and thumb with the direction of the pressure as indicated by the arrows in Fig. 1, this helping to prevent rocking. It is advisable

mens or regular specimens too small to hold can be embedded in suitably-sized annealed brass nuts by forcing them into the bore by light pressure as shown in Fig. 3, which illustrates a piece of aeroplane strut wire. If it is desired to examine the cross section of wire, particularly the smaller gauges, this can be done by drilling a hole fractionally larger in diameter than that of the wire, in a piece of metal, the wire being then placed in the hole and held at the end away from the side which is to be polished by a drop of solder, if necessary (Fig. 4).

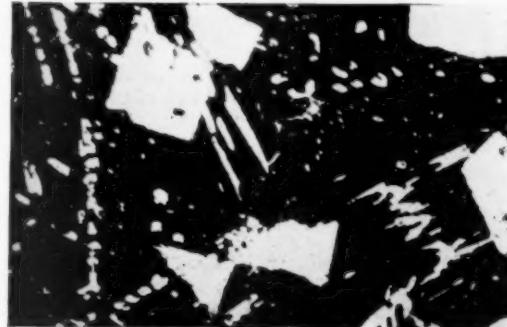


Fig. 6.—Micrograph of 83% tin base white metal. $\times 250$.

After polishing on the file the specimen is transferred to fine emery cloth which should rest on a flat piece of smooth glass at least $\frac{1}{2}$ in. thick, the direction of polishing being changed. With a round or square specimen the new direction can be at 90° to the last, but with rectangular ones the specimen from start to finish should be polished alternately parallel to its longer axis and diagonally. This is so, because polishing parallel to the shorter axis facilitates rocking (Fig. 5.) This change in direction of polishing is only made in order to make the elimination of the previous polishing marks readily detectable. Polishing subsequent to the emery cloth is conducted on jewellers' emery paper, usually grades 0,00,000 and 0000, the last being the finest. It is found that frequently the paper holds fine particles of grit in isolated spots, most probably picked up after manufacture. Any such can be detected readily by laying each paper flat on the glass, which is previously wiped clean, and running over it a straightedge with light pressure applied. If grit is present this discloses it by just breaking the surface of the paper over it. It is a good policy to wipe both glass and paper between each operation, a little care saving a deal of work and extra time.

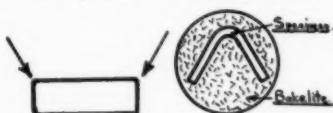


Fig. 1.—Pressure applied to specimen.



Fig. 2.—Embedding strip or wire in Bakelite.

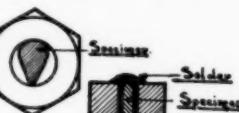


Fig. 3.—Small specimens forced into brass nut for examination of cross section.

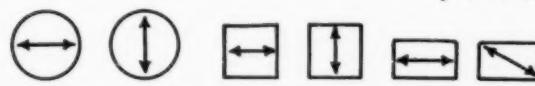


Fig. 5.—Direction of Polishing Specimens.

to mention here that the edges of the specimen should not be chamfered to prevent the possibility of tearing the fine emery as this chamfer will increase any tendency to rock.

Samples of metal strip or wire which it is intended to examine longitudinally can be embedded in Bakelite as shown in diagram in Fig. 2, but polishing must be done carefully with light pressure. Hard small irregular speci-

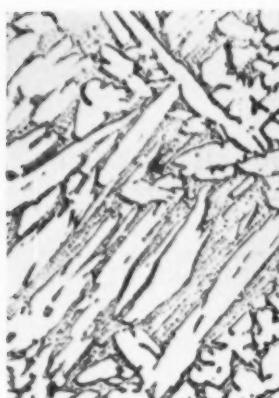


Fig. 7.—Micrograph of an annealed 60/40 brass. $\times 60$.



Fig. 8.—Micrograph of 60/40 brass as cast. $\times 250$.

Polishing on the Buff

The final polish before microscopic examination is done usually on a horizontal mechanical rotating buff, "selvyt" cloth or similar material being most commonly used. It is often found that the soft metals and alloys are polished by hand on chamois leather, using various polishing agents, but this is rarely necessary as it is a simple matter to polish even the softest metals on the buff if the correct procedure is observed. The secret lies in the delicacy of touch. Sometimes the only pressure necessary is that due to the weight of the specimen, the fingers merely being used to hold it in position on the buff. Fig. 6 shows an 83% tin-base white metal X260 polished in this manner. Fig. 7 is an annealed 60/40 brass X60 polished likewise with slightly greater pressure and Fig. 8 the same material "as cast" X250. Fig. 9 is a piece of Thermit copper X260, showing dendrites of free cuprous oxide in a Cu-Cu₂O eutectic ground mass also polished on the buff, and in spite of the friable nature of the oxide the structure is almost free from scratches. Curiously a piece of oxidised copper X65 (Fig. 10) showing dendrites of pure Cu and a ground mass of Cu-Cu₂O eutectic gave more trouble, and although the detail is well defined the scratches are more numerous despite the fact that the amount of oxide is less.

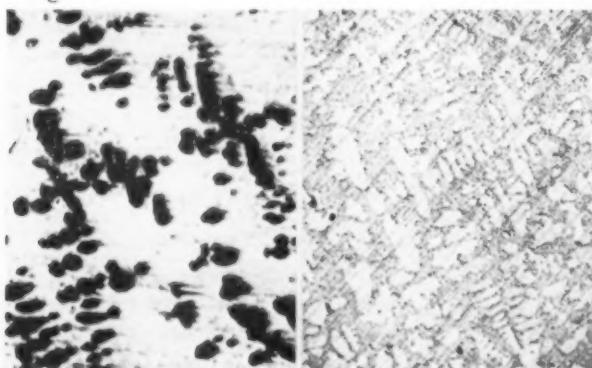
In each case chromium sesquioxide was used as the polishing agent, and for general work it is probably the most suitable to use, although it is "dirty." There are many others in use, but except in one or two cases they show no advantage and often cost much more. The sesquioxide should be prepared by igniting the purest obtainable ammonium bichromate and powdering the "green tea" between the palms of the hands followed by storage in a wide-mouthed stoppered bottle.

Preparation of the Buff

The buff must be prepared carefully if good results are required. Firstly a thorough washing under running

Fig. 9.—Micrograph of a piece of Thermite Copper. $\times 260$.

Fig. 10.—Micrograph of a piece of Oxydised Copper. $\times 65$.



water is desirable with "working" of the surface with the fingers to dislodge old polish, etc. The buff can then be replaced on the machine and excess water squeezed out with the fingers, whilst the buff rotates. This should continue until the buff is moist, but not wet, and then a little of the dry oxide is shaken on and well worked in with the fingers. Polishing can now proceed, and the buff surface is preferably of such a dampness that when the specimen is lightly removed no streaks of water and polish show on its surface. It is thus possible to follow carefully the gradual elimination of the last emery marks. Moistening is done when necessary by the addition of one or two

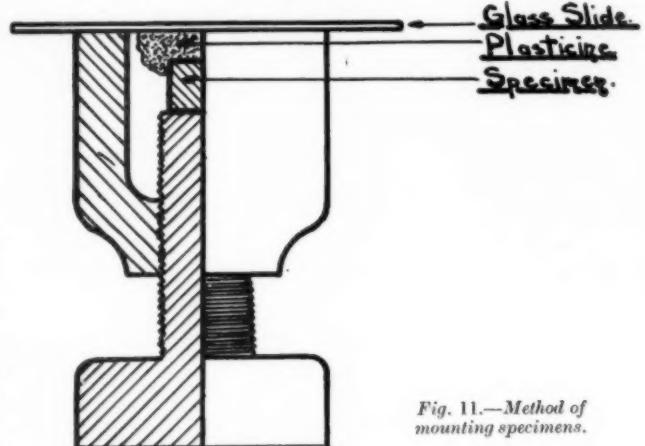


Fig. 11.—Method of mounting specimens.

drops of water centrally, and on no account must the specimen be allowed to drag.

Mounting the Specimens

When using large metallurgical microscopes it is only necessary to mount the specimen on plasticine when requiring to examine the whole of the polished surface but for small bench microscopes plasticine mounting is essential. It can be done readily by the device shown in Fig. 2 which is almost self explanatory.

Science to Help Soviet National Economy

At a recent session of the Academy of Sciences of the U.S.S.R., Academician G. M. Krzhizhanovsky gave an outline of the important work to be carried out by the Academy in 1936. This includes the determination of a scientific method of prospecting for useful minerals, in order to reduce blind prospecting to a minimum, with special bearing to prospecting for tin, rare metals and new oilfields.

Soviet science is to help to create a unified electric power system throughout the U.S.S.R., involving work on the question of high-voltage transmission up to 400 kilovolts, super-high tension, insulation, research on ionic transformation of high-tension currents from alternating to direct. The Academy of Sciences is also to work out a method for the rational exploitation of the gas resources of the U.S.S.R. Work is also to be carried out on the problem of a new type of fuel for internal combustion engines, to meet the rapid increase in the number of tractors and automobiles in the country. The rationalisation of technological processes in metallurgy and the chemical industry, with a view to the better utilisation of equipment is also to receive the attention of the Academy this year.

In order to carry out the plan of increasing the grain harvest within the next three or four years, important work is to be carried out in seed selection, soil chemistry, fertilisers and further mechanisation of agriculture. Work will also be carried out in telemechanics, and in the extension of automatic processes in industry. The Academy is to elaborate a methodology, both economic and technological, for the making of an inventory of the national economy of the U.S.S.R. to serve as a scientific basis for the drawing up of the Third Five-Year Plan.

Silver and its Uses in Chemical Plant

By ARTHUR HASLAM, B.Sc.

The relatively low price of silver has presented many opportunities for its use in industry, particularly the chemical industry, where its valuable properties render its use economical for several purposes. The applications of silver in the chemical industry are briefly discussed.

IN recent years the importance of silver has grown, and it is being applied in industry to a greater extent than formerly. To-day, silver is produced mainly as a by-product of the production of copper, lead and zinc, so that its production is only very little influenced by its market price. In future, therefore, it is to be expected that by-product silver will be produced in sufficient quantity to prevent its price being very much greater than at present. This prospect of relatively cheap silver permits its use in industry for many purposes for which considerably higher prices would make it practically prohibitive. The use of silver in photography, and especially in the film industry, is one of the large industrial uses of the metal, but its present relatively low price opens up many opportunities for its greater use in chemical plant for which its special properties make it particularly suitable.

The physical properties of silver are, generally, very well known. Its specific gravity, according to heat-treatment and degree of working, is from 9.6 to 10.5. Its coefficient of expansion is about half-way between that of lead and platinum, slightly higher than copper, and considerably higher than nickel or iron. The specific heat is low, its thermal conductivity exceeds that of any other metal. This makes silver important where heat transmission comes in question. The electrical conductivity of silver is also greater than that of any other metal, the melting-point is about 960.5° C. Molten silver is volatile to an appreciable extent at 1.00° C., and at considerably higher temperatures, its vapour pressure rises rapidly. Pure silver is characterised by greater malleability and ductility than any other metal except gold, which is very favourable in the working of the metal.

The chemical properties of silver make it of special value for many purposes. Below the boiling point of the metal, it is not attacked by oxygen, water or steam below the decomposition point of the water. Silver is not attacked by strong hydrofluoric acid at ordinary temperatures, or by caustic alkali solutions, including ammonia. Tests have shown that commercial acetic acid, refluxed in the presence of silver for six hours, takes up no silver. Sulphur corrodes silver by mere contact ; at low temperatures, neither dilute nor strong sulphuric acid appreciably attacks silver in the absence of oxidising agents, but silver dissolves readily in nitric acid of all strengths.

The properties which give silver special value for chemical plant construction are : freedom from oxidation ; resistance to various commercial acids ; the remarkably high thermal and electrical conductivities ; and excellent mechanical characteristics. Fine silver is now commercially available as sheets of all gauges down to thin transparent hand-beaten foil ; tubes up to two inches diameter ; both welded and seamless drawn, and wire, either rolled or drawn, down to 0.0005 in.

The most extensive use of silver in chemical plant, so far, is in the condensation and general handling of acetic acid which is particularly corrosive at the moment of condensation, and has given great trouble to manufacturers who usually operate with copper condensers. Many of these copper condensers have been abandoned in favour of silver, with entirely satisfactory results. The heat transmission is so good that a silver condenser for a given duty

can be made considerably smaller than a copper one. The use of silver for plant is spreading to allied trades, and especially in the food industry. In the vinegar trade, fine silver stills, and condensers of silver alloy, tubes, cocks, and taps of silver are being used to overcome the manifold troubles experienced with copper and bronze fittings. In other food-preparing trades, silver is employed for many relatively small uses. In the milk, cider, and brewing trades, silver is used for syphons, pipelines, pasteurising coils, and the nozzles of filling machines.

That silver is without any kind of harmful effect in contact with food is suggested by its frequent use in surgery, in which it is brought into contact with the action of the blood and digestive juices. A common case is that of silver plate used in trepanning where the metal is in contact with the brain.

In the manufacture of acetate rayon silk, silver condensers are used in the recovery of the volatile solvents. In the manufacture of synthetic acetic acid, silver is used as a catalyst in the form of fine wire mesh to promote the oxidation of ethyl alcohol of acetaldehyde ; it is also used in the distillation of phenols. Silver coating of metal is generally known, but a coating of silver-copper alloy is less familiar. Extensive use of what is termed "doublé" is being made ; this is a pure silver sheet rolled on to copper or other base metal. A tube of base metal can be drawn over a seamless tube of silver, the combination being sufficiently strong to withstand a high internal vacuum, while the base metal tube can be made strong enough to withstand a high internal pressure. Coils for heating corrosive liquors can be made in a similar way, but with the silver outside. Small vessels can be made of this "doublé" sheet, but the jointing offers difficulties with larger vessels. Electroplating copper, or other metal with silver is not very suitable for chemical plant ; there are apt to be weak spots in the plating, and the latter is also more or less porous, and liable to be soon destroyed.

Silver is not greatly used in inorganic chemistry operations, as there are many alternative metal materials available which cannot be used for organic processes. For the melting and casting of caustic alkalis, silver is often employed with satisfactory results. Silver, likewise, is a suitable metal in the production of mirror surfaces, and because of its thermal properties, it is used as a deposit on the walls of the ordinary vacuum flask.

Dorman Long to Control Bowesfield Steel Company

The directors of Messrs. Dorman Long and Co., announce that they have acquired complete control of the Bowesfield Steel Co., of Stockton-on-Tees, in the following statement :—

"Dorman Long and Co., which for many years has had a considerable shareholding in the Bowesfield Steel Co., has now purchased the whole of the remaining shares. The Bowesfield Steel Co. will continue to operate as a separate concern."

The Bowesfield Co. is concerned with the rolling of steel products, and has for many years provided a considerable outlet for semi-finished steel produced by Dorman Long. It is anticipated that, in view of the complete control now secured, an even larger outlet will be found for Dorman Long steel production.

Forthcoming Meetings

The Iron and Steel Institute Autumn Meeting in Dusseldorf

The Autumn Meeting of the Iron and Steel Institute will be held in Dusseldorf, September 21-26, by the kind invitation of the Verein deutscher Eisenhuttenleute acting on behalf of the German Iron and Steel Industry. An influential and representative committee has been formed to carry out the arrangements of the meeting with General-direktor Dr. Ing. E. L. Fritz Springorum, as Chairman.

Two morning sessions will be held for the reading and discussion of papers, the first on September 21, in the Schauspielhaus, Karl-Theodor-Strasse 2, and the second on September 22 in the Eisenhuttenhaus, Ludwig-Knickmannstrasse, 27. On the afternoons of these days visits will be arranged to works and places of interest in and around the city of Dusseldorf. The whole of September 23 will be devoted to visits to works in the Lower Rhine district, while the two following days will be devoted to works visits in the Cologne, Dortmund and Mülhern districts, and to works at Essen and Dortmund, respectively.

Extensions of the programme to include excursions to Siegen (foundries and roll casting) or to Saarbrücken (iron and steel works) are being arranged to enable members to visit works in these districts.

The Institute of Metals

Annual Autumn Meeting in Paris

The Twenty-Eighth Annual Meeting of the Institute will be held in Paris from September 14-18, by the kind invitation of the Bureau International des Applications de l'Aluminium with the cordial co-operation of the Chambre Syndicale des Métaux à Paris. The headquarters of the Institute, and the office of the Honorary Local Secretary, will be in the Maison de la Chimie, 28, Rue St. Dominique, Paris, where all the meetings, and a banquet, will be held. An influential Reception Committee (of which the Honorary Secretary is Monsieur J. S. Douchement, a member of the Institute), has been formed to carry out the necessary arrangements.

The meeting will open on Monday, September 14, with the delivery of the Fifteenth Annual Autumn Lecture by Professor P. A. J. Chevenard, on "The Scientific Organisation of Factories." This will be followed by an informal gathering of members. An official welcome will be extended to members in the Amphitheatre of the Maison de la Chimie in the morning of Tuesday, September 15, before the beginning of the first session for the discussion of papers. In the afternoon members and ladies will make visits to works, and in the evening a banquet will be given by the Bureau International des Applications de l'Aluminium.

On Wednesday, September 16, the discussion of papers will continue in the morning (arrangements being made for the entertainment of the ladies meanwhile), and lunch will be served as on the previous day. In the afternoon further visits will be paid, concluding with a civic reception at the Hotel de Ville by the Municipal Council of Paris. In the evening there will be a dance at the Pré Catelan, Bois de Boulogne.

Thursday will be devoted to an all-day motor excursion to Versailles, visiting the chateau, gardens, and other features of interest. A special feature of the meeting will be an optional tour, to be made on Friday, to Rouen, its neighbourhood, and Havre, which will give members an opportunity of visiting a town famous in French history as well as modern metallurgical and engineering works in another part of France.

The following papers are expected to be submitted for discussion at this meeting:—"The Conductivity of Super-Purity Aluminium. The Influence of Small Metallic Additions," by G. G. G. Gauthier; "The Complex Inter-

dependence of the Properties of Alloys, and the Industrial Conditions of their Manufacture, Testing and Use," by Marquis R. and H. Portier de Fleury; "Mechanical Properties of Aluminium and Its Alloys after Prolonged Heating," by Professor A. Zeerleder and Dr. Ing. R. Irmanns, "An Anodic Treatment for the Production of Aluminium Reflectors," by N. D. Pullen; "Mechanism of the Forgeability of various Light and Ultra-Light Alloys," by Professor A. M. Portevin and Dr. A. R. Bastien; "Metals of the Platinum Group: Ores, Recovery and Refinery, Fabrication and Uses, Properties," by R. H. Atkinson and A. R. Raper; "The Creep of Tin and Tin Alloys," by Professor D. Hanson and E. J. Sandford; "Veining and Sub-Boundary Structures in Metals," by Dr. L. Northcott; and "A Note on the Influence of Salt-Bath Heat-Treatment on the Corrosion Resistance of Duralumin Sheet," by A. J. Sidery and B. Evans.

New Analysed Minerals for Students

Bureau of Analysed Samples, Ltd., 3, Wilson Street, Middlesbrough, who have recently taken over the supply of British Chemical Standards from Messrs. Ridsdale and Co., Ltd., announce the issue of a further series of standard analysed samples of minerals specially prepared for the use of students, works chemists, and others associated with the buying, selling, and smelting of minerals.

The list is as follows:—

Zinc Concentrates	analysed for	Zn, S, Fe, Pb, Cu, As, Mn, Cd, CaF ₂
Lead Concentrates	"	Pb, Zn, Ag, Cu Bi, Au, Sb, As, Cu, Fe, Mn, S
Iron Pyrites	"	Cu, Se, As, Co, Zn
Burnt Pyrites	"	Cu, Fe, S
Copper-lead Matter	"	Cu, Pb, Ag
Copper-nickel Speiss	"	Cu, Pb, Ni, Co, As, Ag
Tin Concentrates	"	Sn, W, As, Cu, Pb, Bi, S, Fe, Mn

Each sample has been carefully analysed by three different chemists experienced in this class of work.

No doubt many chemists will be glad to have standard samples tested for some of the less common elements (notably selenium) shown above and including assay figures for silver and gold.

Samples are only packed in bottles of 100 and 500 grms. of each, and prices are from 10s. 6d. per bottle.

Further particulars may be obtained from the Bureau.

The Copper Cliff Concentrator

The large concentrator at Copper Cliff, Ontario, was described in some detail by Mr. W. T. MacDonald, in a recent paper before the Canadian Institute of Mining and Metallurgy at Sudbury. The mill has now an ore capacity of 11,000 tons daily, and 1,100 gallons of water are used in the cleansing of every ton of ore washed. Last year, for instance, the mill utilised 2,000,000,000 gallons of water in its operations—a quantity which would fill a lake one mile square and 10 ft. deep. Of the water used, of course, only one-third is, in fact, making its first trip through the plant and the remainder is reclaimed from the concentrate or tailing and used again.

All of the ore from the Frood and Creighton mines is brought by rail to Copper Cliff or Coniston, and under ordinary conditions ore coming to Copper Cliff passes through the concentrator. About 90% of this ore comes 4½ miles by rail from the Frood mine, whilst the remainder comes 9½ miles from Creighton, in bottom-dump cars of 70 tons capacity. In 1935, over 36,000 carloads of ore were treated at Copper Cliff. As soon as it reaches the mill from the mine, the ore is dumped into receiving bins of 10,000 tons capacity, from which it is carried by conveyor belt through the mill to the smelter. In the Copper Cliff plant there are over three miles of belting. The paper described in detail the crushing, screening, milling and oil flotation operations at this plant, which is the largest of its kind in Canada, and believed to be also the largest in the British Empire.

METALLURGIA

THE BRITISH JOURNAL OF METALS.
INCORPORATING "THE METALLURGICAL ENGINEER"

Specifications for Materials

THE gradual development of improved methods of production and the increased complications of service conditions have led to some form of grading of materials which is recognised as a specification. In general, material specifications have been developed as an economic necessity, they indicate that thought and study have been given to the service requirements for which a particular material is intended, they constitute a check on materials supplied, and facilitate subsequent work with these materials, they are essential to the large consumer, and ensure materials of uniform quality when obtained from different sources, they promote the best use of materials for each particular purpose, and in a measure constitute a guide for economical buying.

The number of different materials used by any large consumer is enormous, particularly in the engineering industry, and the basis of manufacture is dependent upon the maintenance of a certain standard of quality of each material used. The user of metals for instance, buys to a specification, either his own or the manufacturer's, and tests are generally applied to ensure that the metal fulfils the requirements of the specification. In the majority of instances standard specifications are quoted by the user when ordering supplies. In this country the details of tests, to be applied to ferrous and non-ferrous metals, and the results to be obtained are contained in various B.S.I. specifications, although other standard specifications, such as D.T.D. specifications, which are issued especially for aircraft work, are also applied.

The British Standards Institution assume responsibility for specifying a material only when it is in thoroughly established general use. Comparatively new or experimental materials may remain without recognition for a long time, even though tests show it to be superior for a particular purpose than the material usually employed for that purpose. In fact, so wide is the range of metals and alloys, that the tendency is to bring about some limitation by standardisation. Take the case of steel, for instance, there are many hundreds of varieties manufactured to-day, each having its own particular uses. Steel in its commercial state can be classified into two groups: straight carbon and alloys steels, each of which can be sub-divided into hardening, casehardening, cold-worked and tool steels. The second group also contains a large range of stainless and heat-resisting steels each having its own special properties.

As is well known, the most significant constituent of steel is carbon. Chemically this is an impurity, that is, absorbed by the iron during its process of manufacture, but actually it is a most important constituent and is deliberately introduced in certain quantities in order to regulate the properties of the steel being made. The carbon controls the strength, toughness, etc., of the steel by reason of its response to various kinds of heat treatment. Alloys are used in steels to overcome certain limitations of carbon steels and to increase their mechanical properties. Alloy steels are usually more difficult to produce and consequently, more expensive, and also need special treatment and care during the processes involved in their use on production. Nickel, chromium, molybdenum, titanium, and tungsten are the chief alloys introduced in addition to

carbon, manganese and silicon. In all steels, however, phosphorus and sulphur are present as impurities and since the contents of these elements must be low the maximum content is frequently specified.

The maximum mechanical properties of carbon or alloy steels are dependent upon some form of heat treatment. It is by this operation that alloy steels, particularly, give improvements in tensile strength, and in what is more important in many cases, a greater constancy in impact values. But the heat treatment of steel to improve its properties generally necessitates heating to a hardening temperature and subsequently it is tempered at a temperature at which will be produced the particular characteristics required of the steel. A low-tempering temperature will produce a steel of high-maximum stress, but of low-impact and elongation values. A relatively high-tempering temperature, on the other hand, will give low tensile strength, but would be very tough. With such a wide range of steels, the majority of which are improved by heat treatment, it is necessary to use a treatment that will produce a steel consistent with the requirements of a particular test specification. Thus, the most suitable heat treatment is specified.

In addition to standard specifications manufacturers of ferrous and non-ferrous metals almost invariably supply specifications varying with the form in which the particular metal is marketed. Such specifications are valuable to the user, although, in every instance they may not comply exactly with the requirements of the buyer. With the manufacturers specifications much useful data is usually associated; the object being to give definite instructions on the manipulation of the material so that it will respond favourably to subsequent tests. In the case of many steels, for instance, not only are analyses given, but the heat-treatment which should be given to produce certain mechanical properties, in addition helpful information is given to facilitate fabrication and to ensure that excessive strains are not imposed upon the steel during the working operations.

However good a steel may be in its commercial form, want of care in fabrication may prevent it subsequently producing the results required from tests in its finished form. During forging or heating and cooling operations the structure of the steel may be ruined, for this reason manufacturers, after much research and experiment, assist the user by giving essential information in working the steel. In some cases there are dangers in heat treatment which are not entirely guarded against in official specifications. In the heat treatment of some aluminium alloys, for instance, it is possible to spoil material by overheating without going so far as to cause it to fail to pass the specification tests for maximum stress, elongation, and such properties, but ordinary micro-examination of the structure will show up the enlargement of crystals. Fatigue tests or twisting tests on suitable specimens of an aluminium in this condition will disclose its weakness.

Generally official specifications, that is, B.S.I. specifications, or other specifications which are prepared by an organisation, are of greater value than the manufacturers specifications because they represent the results of a common effort of the various interests involved, and they form a valuable guide to users, but many users have problems of their own, which, as a result of investigations,

call for modifications to the standard specification. In such cases the user may draw up his own specification for a particular material, the appropriate standard specification being used as a basis. This is very helpful to a manufacturer who can invariably make suggestions which will satisfy requirements. Generally it can be stated that the highest and best use of a material will be promoted by a full knowledge of its possibilities as embodied in a complete specification.

The Centenary of a Famous Non-Ferrous Metal Company

A UNIQUE event in the history and development of the non-ferrous metal trade occurred on July 1, when the centenary of The Birmingham Battery and Metal Co., Ltd., was celebrated. This firm, one of the oldest in the trade, was formed on the 1st July, 1836, in premises situated at Digbeth, near to the centre of the city of Birmingham, and adjacent to the site of the Manor of the family from which the town derived its name. So great was the demand for the products of The Battery Company, as it was then named, that in time more spacious premises became necessary to cope with expanding trade, and the factory was removed to its present extensive site at Selly Oak. As a manufacturing organisation the firm's fame became world-wide, and keeping pace with the times, and by the instalment of modern and always up-to-date plant, the works have evolved into a leading position in the non-ferrous trade, covering, as it does, the manufacture of sheets, tubes, wire, plates and the like to all specifications. In recent years a stamping plant has been erected on what was the site of a gas-generating scheme.

The passing of the 100th milestone in the development of the company was quietly observed by the firm's recognition of the services of office and works staffs and workpeople, a number of the latter having been in their employment for periods over 30 years. That a perfect working understanding exists between the directors and their employees is reflected by the fact that the latter reciprocated the former's cognisance of service by suitable presentations which are to find a permanent place in the board room of the company at their head office in Selly Oak.

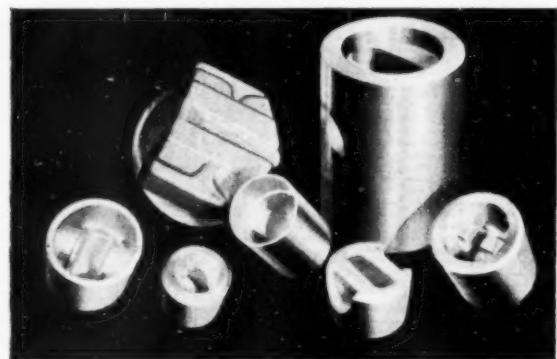
Machinable Cast-Iron Welds

When cast iron is welded with a steel or iron electrode the fusion point is extremely hard and non-machinable, and the surface can only be finished by grinding. For this reason Monel metal electrodes were introduced and experience has shown that, with proper welding apparatus, they give a surface capable of being machined as readily as the parent metal. Coated Monel metal rods are available for the metallic arc welding of cast iron, while bare Monel metal wire is used for oxy-acetylene welding and refined powdered borax should be used as a flux.

Welding with Monel metal requires some experience for successful results. As a rule the work should be flat and the metal deposited on a cold section of the casting, with a bead no longer than two inches laid at one time. Immediately after breaking the arc, this bead should be peened with a light ball peen hammer. In addition to peening, caulking should be continued after every second layer is completed. Particular care should be taken to deposit each and every 2-in. bead on cold metal; it is therefore necessary to either keep moving from one part of the casting to another, or to cease welding operations until the metal has thoroughly cooled down. Welding cast iron must necessarily proceed slowly, and where the above suggestions have been conscientiously adhered to by the operator satisfactory results should be obtained. Current at 175 amperes and a short arc are recommended for using Monel metal, 0.148 in. (1/2 in.) diameter; 100-130 amperes for 0.120 in. (1/8 in.) diameter, and 80-100 amperes for 0.093 in. (1/32 in.) diameter.

Wrought Aluminium Alloy for Parts Working at Elevated Temperatures

The modern demand for increased power for a given capacity in internal combustion engines has brought with it great increases in cylinder temperatures and stresses, hence the demand for stronger and more reliable piston material. This trend has been most marked in the case of the high-performance aero-engine, where wrought-piston materials have been used almost exclusively for some years, while recent development of the compression ignition engine has shown the necessity for forged aluminium alloy pistons.



Typical parts in Hiduminium R.R.59.

For this purpose Hiduminium R.R. 59 has been developed. Piston forgings in this alloy possess a very high degree of homogeneity. They have great strength and resistance to static and dynamic stresses both at normal and at elevated temperatures, and the combination of these characteristics, together with favourable conductivity and expansion co-efficients, results in reliable piston material for arduous service.

This alloy, which is also used extensively for other parts subjected to high engine temperatures such as cylinders, cylinder heads, etc., is also available in the form of die stampings, pressings, or hand forgings, its heat treatment consisting of a solution treatment of 2-4 hours, at 530° ± 5° C., followed by quenching and an ageing or precipitation treatment of 16-20 hours, at 170° ± 5° C.

The physical and mechanical properties of this alloy are as follows:—

Specific gravity	2.75
Co-efficient of thermal expansion	20°-100° C.—22.0 × 10 ⁻⁶
	20°-200° C.—23.1 × 10 ⁻⁶
	20°-300° C.—24.0 × 10 ⁻⁶
	20°-400° C.—24.8 × 10 ⁻⁶

Thermal conductivity 0-100° C. C.G.S. units	0.428
---	-------

Thermal conductivity as a percentage of copper	46.5
--	------

MECHANICAL PROPERTIES OF HEAT-TREATED FORGINGS.

Fatigue limit at 40,000,000 reversals	Tons/sq. in.	Stamping and Hand Pressings.	Large and Hand Forgings.
Ultimate stress in tension	26-28	23-26	—
0.1% proof stress in tension	20-22	19-21	—
Elongation % in 2 in.	6-12	3-5	—
0.1% proof stress in compression	21-23	—	—
0.5% proof stress in compression	25-27	—	—
Brinell hardness number	124-148	—	—

PROPERTIES AT Elevated TEMPERATURES.

Temperature.	Ult. stress. Tons/sq. in.	Brinell at Temperature.	Brinell after Cooling.
20° C.	28.0	134	—
200° C.	21.5	110	134
250° C.	19.5	87	125
300° C.	13.0	52	90
350° C.	8.0	27	75
400° C.	—	12	70

Some Metals and Alloys Used in Steel Making

Much has been written regarding alloy steels; comparatively little attention, however, has been given to the materials which are essential in their manufacture. In this article some of the alloy metals are discussed, with special reference to tungsten, vanadium and molybdenum and the forms in which they are used to provide the alloy contents of steel.

FOR many years the addition of various alloying metals to iron and steel has aroused the interest of investigators, and as a result of much research and experiment it has been shown that certain elements produce marked changes in the properties of steels, and the outstanding advantages obtained have given steels of this character a very high commercial value. To-day, there is an increasing tendency to use alloy steels in preference to carbon steels for parts subjected to severe service conditions, and their application is so widespread that they are now essential to progress. It is only necessary to consider the importance of alloying metals on tool steels, the high-tensile steels used in aeronautical and automobile engineering, corrosion and heat-resisting, magnet steels, wear-resisting steels and many others with special properties, to appreciate the value of alloying metal in the manufacture of high-grade steels.

To a more or less extent silicon, manganese, nickel, chromium, tungsten, vanadium, cobalt, molybdenum, copper, aluminium, uranium, titanium, zirconium and other metals are used, either alone or in association, to form a more complex alloy steel. The inclusion of two, three or more of such metals in variable proportions produces innumerable alloy steels, each with characteristic physical qualities, developed for particular conditions of service. Until comparatively recent years some of these metals were rare and almost unknown outside of the laboratory; to-day they have become intimately associated with steel manufacture, and in this article it is proposed to discuss some of these metals, with special reference to tungsten, vanadium and molybdenum and the forms in which they are used to provide the alloy contents of the steels.

It is appreciated that the consumer of alloy steels is concerned primarily with physical properties, and it is the steelmaker's problem to obtain these properties by the skilful admixture of alloy metals and suitable heat treatment, for which purpose suitable alloy metals must be selected which are as free as possible from impurities. The chief impurities to which steelmakers take exception are sulphur, phosphorus and arsenic. These are widely distributed and found in almost every mineral. In some cases in fact, the minerals are sulphides, and thus sulphur is an essential constituent. The elimination or reduction to negligible proportions of impurities in alloying metals is possible in practically every case, but the lower the percentage to which these impurities are reduced, the greater is the cost of the finished product. From an economical point of view, therefore, an impurity should only be reduced to that percentage at which it is harmless when used in the particular steel to be manufactured.

Nickel

This important alloying metal is found in very complex ores, and its extraction has been the result of numerous investigations. Before the discovery in 1865 of the New Caledonian ores by Jules Garnier, and later of the Canadian ores, the most important ores of nickel were "kupfer-nickel" or arsenical nickel, occurring in Germany, France and Australia; nickel sulphide ores mined in Cornwall, Scotland and Wales; nickel serpentine (Garnierite) worked in the Russian Urals, Italy, Spain and America. The pyrrhotite—chalcopyrite ores similar to those of Sudbury, Canada, occurring in Norway, were, prior to the discovery

of the New Caledonian ores, the principal supply of the metal. The Sudbury ore is chiefly a compound of nickel, copper, iron and sulphur, and is described as nickeliferous pyrrhotite. The production of pure nickel and pure copper from this mineral has been a subject of much technical investigation and by methods of smelting, electrolysis and the carbonyl process of Mond recovery and refinement of the nickel has been brought to a very perfect stage yielding nickel of over 99% purity.

Although nickel had been alloyed with iron as early as 1820 by Faraday, it was not until after 1870 that serious consideration was given to the study of steels containing this element. The French commenced a series of experiments which culminated in the successful production of a nickel steel by Marbeau at the Montataire works in 1885-1887. In 1889 James Riley gave a paper on "The Alloys and Nickel and Steel" before the Iron and Steel Institute, and this, together with the work in France, marks the beginning of the commercial development of nickel steels.

Chromium

Discovered as long ago as 1797 by Vauquelin, a Frenchman, it is only during comparatively recent years that the value of chromium has been appreciated and its use extended. One of its rarer ores, chromate of lead, was first investigated by Vauquelin and Macquart in 1789 and in 1797 by Vauquelin, who found that the lead was in combination with an acid, which he recognised as an oxide of a new metal. The chromate of lead or crocoisite, upon which these investigations were made, is frequently associated with other ores, but no workable deposits are known. The only important source of chromium is chrome iron ore, or chromite. Rhodesia produces a very large proportion of the world's requirements of chromite, but large deposits are also successfully worked in many other countries, notably those in Bosnia, Cuba, South Africa and Japan.

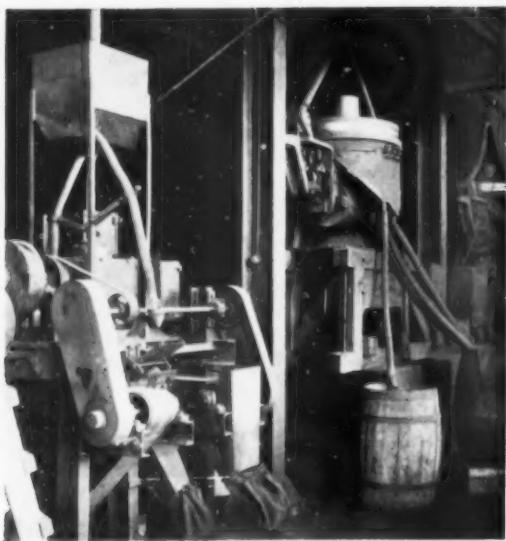
The mineral is extremely refractory and can be resolved into its constituents only by strong chemical action or the heat of an electric furnace. To recover pure chromium oxide for producing chrome metal and the many salts of chromium, the initial step is melting with soda and lime to form sodium chromate.

The oxide recovered from this can be reduced by aluminium for the production of pure chromium metal, for which there is a demand by alloy makers for special purposes. The bulk requirements of the steel trade are filled by ferro chrome, produced by smelting chrome iron ore with carbon in electric furnaces, and the amount of electricity required is such as to necessitate this operation being carried out mainly where water power is available.

Chromium has a strong affinity for carbon and ferro chrome may contain 8-10% of carbon. Varying grades are made according to carbon contents, and a very considerable demand has arisen for very low-carbon alloy for the production of stainless steel and iron.

Tungsten

The history of this metal is very instructive. In metallic form it was probably obtained in very early times, but it was frequently confounded with tin. In 1781 Scheele isolated a new acid from the mineral now called Scheelite, a natural calcium tungstate. The name tungsten had



Magnetic separation plant.

previously been applied to the mineral, and the new acid was called tungstic acid. Bergman, in the following year, detected the same acid in wolframite, and the metal and some of its compounds were subsequently prepared in his laboratory.

Tungsten-bearing ores are widely distributed, but never occur in massive form. It is generally disseminated through quartz lodes and almost invariably in association with tin oxide. The largest deposits at present known are in the continuation of the Indo-Malaya mountains across Asia, traversing Burma, Malaya, China and Japan. Commercial production also is carried on in Portugal, Bolivia, Argentine, Australia, U.S.A. and Cornwall.

Comparatively little of the tungsten ore is mined from lodes, the bulk being recovered from alluvial deposits formed by age-long weathering of the mountains and hills in which the lodes previously existed. The concentration of tungsten ores is effected with comparative ease, by wet-gravity methods, owing to the extreme weight of the mineral which separates easily from other constituents except tin oxide.

The tungsten ores are Scheelite which is non magnetic, but as a rule almost free from Tin and Wolfram, which is sufficiently magnetic for separation from tin oxide by magnetic separators.

The methods of extracting tungsten differ according to the particular type of ore. Scheelite ores are usually digested with concentrated hydrochloric acid, when the trioxide separates. Wolfram also may be treated with acid to dissolve the iron and leave the Tungsten Trioxide, but in practice the method employed is to heat the mineral with soda, form sodium tungstate which is soluble and iron oxide which is not.

The melt is ground and boiled with water, and the solution of sodium tungstate after filtration is acidified to produce tungsten trioxide. The trioxide is reduced to metal by admixture with carbon and heating in suitable furnaces.

The first use of tungsten in connection with steel was probably in the manufacture of Mushet steel, but its use gained more prominence about 1890, from which time it gradually became recognised that tungsten in steel gave it the property of retaining its hardness at high temperatures. At first the application of tool steels containing tungsten was slow, because the machine tools then in use were designed for the slower speeds and lighter cuts required for carbon-steel tools. Gradually, however, the high-speed steel industry progressed and was well established by 1900.

The desire among high-speed steel manufacturers to improve their product resulted in the contents of tungsten

being increased, and in the addition of vanadium and other metals. The steadily increasing percentages used in steel created problems in manufacture because of impurities, such as tin, sulphur, phosphorus and arsenic, and to avoid these a demand arose for pure tungsten. For Mushet steel, the tungsten was originally introduced as wolfram ore, its reduction taking place in the crucibles with all the impurities in the ore being present and liable to contaminate the steel. With the steady demand for a purer tungsten it was prepared in powder form having a content of 96/98% tungsten, made entirely in Germany. Under the Great War conditions, tungsten powder production was started in England, and the quality of this is 98/99%. Some ferro tungsten was used before the War, but tungsten powder was given preference until more recent years when the production of ferro tungsten to stringent specifications led to its greater use in steelmaking.

Vanadium

The history of vanadium is comparatively short, since its introduction in steelmaking barely antedates the present century. It was first discovered by Del Rio in 1801, and occurs only in combination in a number of minerals. The chief ores are patronite, a sulphide, and at one time the main source of the element; mottramite, descloizite and other minerals of slightly varying constituents.

The first commercial production of vanadium was from patronite mined in Peru and smelted in U.S.A. Of late years the lead vanadium and lead zinc vanadium minerals of Rhodesia and S.W. Africa have been developed on a large scale and to-day provide probably the greater proportion of the world's requirements.

In all cases the first step is to isolate vanadium pentoxide (V_2O_5), and this is subsequently reduced to metal by aluminium. Sufficient pure iron is added to give ferro vanadium of the desired grade—from 30%—80% V. Steelmakers stipulate for freedom from detrimental impurities such as phosphorus, sulphur and arsenic, but as steel contains a maximum of 1½% vanadium, and generally much less, all impurities in ferro vanadium are reduced by 90% or more when calculated on the steel.

Molybdenum

Although discovered by Scheele in 1778, molybdenum received very scant recognition until about 1914. Its use for commercial purposes was stimulated during the war, and as a result of considerable research since that time its use has grown at a rapid rate, particularly in the manufacture of steels for highly-stressed parts. In tool and high-speed steels also the use of molybdenum is increasing, especially in America, where it is being used to some extent instead of tungsten.

Molybdenum occurs in nature mainly as molybdenite, a disulphide, which strongly resembles graphite in appearance. The other commercial sources are wulfenite, a lead molybdate, and molybdite, a hydrated ferric molybdate occurring as an oxidation product of molybdenite. This metal is widely but sparsely distributed through the earth's

Part of the chemical plant.



crust, the ores rarely containing more than 1% of molybdenite, which is disseminated through the rock in small scales and grains, and, after being freed by fine grinding, the sulphide is separated from the rock by froth flotation. The concentrates are subsequently treated to produce molybdenum metal powder, which is available with molybdenum content of 95/97 and 99% minimum; ferro molybdenum containing 60/70/80%; molybdenum; calcium molybdate containing 40-50% molybdenum; and "Molyte" a special product containing 40-50% molybdenum.

HIGH-SPEED STEEL ALLOYS, LTD.

Earlier in this article it was stated that 96-98% tungsten metal powder was principally used for the manufacture of high-speed steel up to 1914. Since this was obtained from Germany, circumstances at that time necessitated a change. With the country at war the demand for tungsten increased to deal with every mechanical detail for munitions of war. After investigation into ferro tungsten, made by special processes, it was finally decided that a factory to produce tungsten metal powder was essential and the Government approved of high-speed steel manufacturers opening a factory for this purpose.

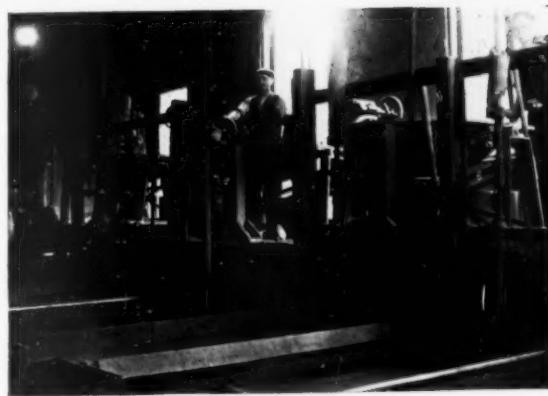
The work was taken in hand by a Committee of high-speed steel makers, and Mr. J. L. F. Vogel, M.I.M.M., M.I.E.E., was engaged to design and erect a suitable works and start up on a production basis under the title of High Speed Steel Alloys, Ltd. Production began in July, 1915, at Widnes, and the powder produced ran about 1% higher in tungsten contents than the metal supplied in pre-war times by the Continental makers, and in freedom from impurities detrimental to steel was not surpassed by material of other origin. At the conclusion of hostilities over 4½ million pounds of tungsten powder had been produced by this Company.

Although these works were initially designed for the production only of tungsten metal powder, considerable extensions were made to meet an increasing demand, and the capacity for tungsten powder has been out of proportion to the average demand since 1920. The buildings and plant thus available have in many cases been adapted for the production of other metals, alloys and chemicals. New departments have also been specially designed and erected for particular work or output. To-day the products include tungsten powder, chromium, manganese, molybdenum powder, and vanadium; ferro alloys of tungsten, vanadium, molybdenum, chromium, and titanium; cupro-manganese and cupro-vanadium; tungsten carbides, molyte and calcium molybdate; and also numerous fine chemicals. The writer had the privilege of visiting these works recently and a brief description may be of interest.

Laboratory

The laboratory is naturally essential for the scientific control of products of this character. The work carried out

Crucibles entering tunnel furnace.



Washing and drying tungsten metal.

comes under two main categories: analytical and research. All raw materials are assayed with the object of checking purchases. Process intermediates are weighed and sampled at various points in the course of manufacture and analyses of their metallic contents made with a view to the efficient operation of the plant. All metals, alloys, and chemical compounds leaving the works are sold on a guaranteed analysis. Representative samples of each parcel are carefully examined for the determination of their principal constituent and freedom from injurious impurities before the bulk material is delivered to the purchasers.

The research department is concerned primarily with work of an investigatory character. The field covered is wide and embraces all the metals or their compounds produced by the Company, and may vary from improvements in methods of refining the ore to the preparation of the purest salts. This department is well equipped with furnaces mostly electrically heated, in which temperatures up to 1,800° C. are readily obtained, with temperature measurement and control equipment. A complete outfit for the measurement of hydrogen-ion concentration and electrolytic potentials is another example of the provision of modern appliances.

The Works and Processes Employed

The works cover an area of about six acres, the greater part of which is occupied by buildings. The rail-borne raw materials consisting of ore, fuel, alkali, and acid, are delivered on to a siding, but in recent years increasing use of road transport has been made. The principal manufacturing processes visited were those employed for the production of tungsten powder, ferro vanadium, ferro molybdenum and ferro tungsten. In the case of the first three the essential aim of each process is identical, since an oxide of the metal is obtained from the ore, purified and subsequently reduced to metal. In the case of ferro tungsten, the ore itself is first purified before such reduction.

Part of the original tungsten metal powder plant has been adapted and utilised for the production of vanadium; the preliminary tungsten and vanadium processes run side by side up to the stage where the soda salts of the metals are separated from the other contents of the ores. The vanadium process is continued in another department and completed in the ferro department.

In the case of the tungsten, the ores, crushed in a mill and then sized by screening, are concentrated by magnetic separation, which also recovers any tin ore present. The refined concentrates are ground in ball mills for subsequent treatment in the production of tungsten metal and ferro tungsten. For tungsten powder the ground tungsten ores are blended, mixed with soda ash and then heated in reverberatory furnaces. The "melt" from the furnaces is subsequently broken in jaw crushers and ground in ball mills before being conveyed to the next department where it is fed to dissolvers capable of boiling solutions under pressure. The tungsten, which has been rendered soluble



A corner of the thermit department.

by the action of the soda ash, is separated from the other constituents of the ore by filtering. The solution of tungsten state of soda is then concentrated in tubular evaporators. This concentrated solution is passed to another department where it is treated with acid to produce yellow tungsten trioxide, which is washed and freed from excess water. This oxide is subsequently dried, calcined, and ground in a disintegrator. The ground oxide is then mixed with a carefully measured quantity of carbon, charged into crucibles, and heated in a tunnel furnace. The crude metal obtained from the tunnel furnace is picked, ground, washed and dried. The finished product assays 98-99% tungsten, and is usually packed in 2 cwt. drums ready for despatch.

The production of vanadium involves the use of totally different processes according to the class of raw material treated. The problem in all cases is to obtain a soluble sodium vanadate by furnace treatment, followed by solution and acid precipitation of the vanadium oxide. In furnacing lead vanadium ores, the lead is reduced to metal and run into pigs, the sodium vanadate forming the slag.

The varying grades of ferro vanadium are produced by alumino thermic reduction of the vanadium oxide in admixture with the necessary amount of iron.

It is noteworthy that all the crucibles used in the tunnel furnaces are made at these works. Fireclay, plumbago, and "grog" are mixed with the necessary quantity of water in one of two mixers. A weighed quantity of the mixture is "pugged" and allowed to stand 24 hours before being pressed in one of the hand presses. Crucibles

Part of the general warehouse.



are allowed to stand for several weeks or even months in a warm, dry atmosphere before use in the furnace.

Tunnel Furnaces

A noticeable feature of the plant are the tunnel furnaces for heating crucibles. These, heated by producer gas and arranged for continuous working, are in constant use, one of them having been put into operation in 1917, and being still in use. This furnace, which is 130 ft. long, is built of brick, and the crucibles are carried on bogies which run on rails and are isolated by side curtains running in sand troughs. The bogies carry a super-structure of firebrick, on which the crucibles rest at a suitable height to meet the fire gases and ensure a maximum utilisation of the heat.

A tunnel runs under the track and the air for the combustion of the gas travels through this, thus cooling the bogies and slightly preheating the air. The air thus introduced is passed by a pressure fan into the side walls at the exit end of the furnace, and finally enters a double arch over the burner section where it rises to a high temperature before mixing with the producer gas. The furnace holds 27 bogies. At intervals one is drawn out by hand from the exit end, and a fresh charged bogie is pushed in at the charge end, moving the whole train forward by exactly the length of one bogie. The exit gases are drawn through an exhaust fan, and, by suitably adjusting the speed of the two fans, the speed of travel of the gases can be adjusted to give the desired heat distribution, which is controlled by pyrometers.

Ferro Alloys

Ferro vanadium, ferro tungsten, ferro molybdenum and all alloys made by the thermit process are manufactured in the ferro department. The ores or other products are mixed with the different reducing agents in one of three mixers and the mixed charges are fired in special pots lined with magnesite. The fused mass of slag and metal is allowed to cool, the pots emptied, "slagged," and the blocks of metal cleaned. The metal is then broken under the tups to convenient lumps and these are crushed to required sizes and packed for despatch.

In addition to the manufacture of these metals and ferro alloys used by steelmakers, the chemical processes necessary to obtain some of these metals from ores containing a relatively small percentage, give intermediates which can be used as a convenient source of chemical compounds of the metals concerned, and which are now included among the products of the Company.

The writer takes this opportunity of expressing his thanks to Mr. J. L. F. Vogel, General Manager, for permission to visit the works, Mr. F. J. Tonks, Chief Chemist and his staff for their explanation of the various processes.

Iron for Buoyancy Tanks

As a result of tests, it is announced that the Board of Trade have approved the use of Armeo ingot iron for the buoyancy tanks for life-saving appliances. This will effect considerable saving in the shipbuilding industry, because in the past non-ferrous metals have been exclusively used. Certain conditions have been stipulated under which Armeo ingot iron may be used for this purpose; thus the thickness of the sheets must not be less than 23 Birmingham gauge in the black state; each sheet must be stamped with the makers' registered trade mark for identification purposes, the marks being not more than 12 in. apart; and the sheets must be galvanised either before or during construction of the buoyancy tank.

This iron is not claimed to be rustless, but it is rust-resisting to the extent that pitting is almost entirely eliminated, while the oxide film is hard, uniform and tightly adherent, and it is claimed that this film gives better protection to the metal than is possible with a less pure iron.

Phosphor-Bronze Bearings

By a Special Contributor

True phosphor bronzes carry a definite and appreciable amount of phosphorus, and although compositions were used for bearings in the early days of metallurgical science, we know to-day their application has been confirmed by subsequent enlightened research and the bearing bronzes are still regarded as essential to successful service. In this article the author discusses the composition of phosphor bronzes for bearings, the function of hard and soft constituents, the adjustment of tin and phosphorus contents, and the influence of various alloy additions.

SMALL amounts of phosphorus are frequently introduced into bronzes for deoxidizing purposes, and such alloys are sometimes referred to as phosphorised or phosphor bronzes, which is very misleading. When phosphorus is used for this purpose the phosphorus content in the finished alloy amounts to a trace only, and such negligible amounts have little or no effect on the properties of the bronze other than that due to more thorough deoxidation. The term phosphor bronze became commonly misapplied despite the fact that there was an older, more correctly named class of alloys under this name which carries an appreciable percentage of phosphorus.

The first definite record of the use of phosphorus bronze is in 1854, when Roulz used phosphor bronze on the Orleans railway. It will be noted that this occurred at a time when metallurgical analysis was still in an embryo state, before the days of the constitutional diagram. Bronzes, of course, are as old as civilisation itself, but that the non-metal

made from phosphor bronze, and to-day more strictly controlled alloys are used almost exclusively for this purpose.

Range of Composition

The composition of the phosphor bronzes vary somewhat, but the range useful for bearings has between 9% and 14% tin, with 0.1% to 1.0% phosphorus, and the remainder copper. The most popular alloy and one which gives excellent service under a great variety of conditions has a composition and properties as follows:—

Composition.		Mechanical Properties.	
Tin	11%	Maximum stress	17 tons per sq. in.
Phosphorus	0.3%	Yield point	10 "
Lead	0.2%	Elongation	10%
Iron (max.)	0.1%	Elastic limit	in
Zinc (max.)	0.1%	compression	7 tons per sq. in.
Copper	remainder	Brinell	85



Fig. 1—Phosphor bronze showing the soft matrix of solid solution (dark) and the hard constituents (light). Magnification 75.



Fig. 2—The hard constituents in Phosphor bronze. Magnification 1000.

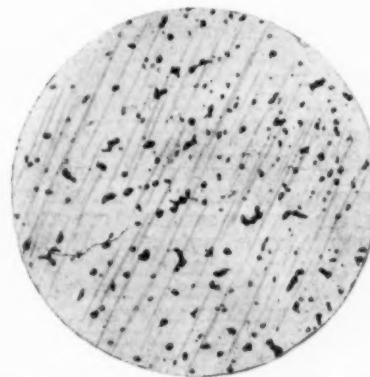


Fig. 3—Leaded phosphor bronze, showing the leaded globules. Magnification 75.

phosphorus should ever have been incorporated in these alloys can only be regarded with surprise. It is still more surprising that the particular mixture used should have been confirmed by subsequent enlightened research as the optimum composition for phosphor bronze. The close study of these alloys during recent years has resulted in the introduction of many refinements, but the essential basis alloy is still much the same as when it was first developed.

About the time when Roulz, first used phosphor bronze several European governments took up the study of these alloys. Experiments were carried out at Woolwich Arsenal under the supervision of Weston and Abel; Monifore, Levi, and Kunzel conducted researches for the Belgian Government, and later for the Russian Government. The work done by Professor Kunzel during this period was of such outstanding importance that he is now generally acknowledged as the inventor of phosphor bronze. It was originally found that bearings gave successful service when

Function of Hard and Soft Constituents

No matter of what class of alloy the bearing metal is made, accumulated experience has shown that certain requirements are essential to successful service. The microstructure of the alloy must be of a distinctive type, and should consist of a more or less plastic ground mass, in which is embedded a number of relatively hard isolated particles. The function of the hard particles—or hard network, as it may sometimes be—is to resist the abrasive and tearing action of the revolving shaft, and to maintain a true-to-size working surface. The matrix of the alloy should be ductile enough to "bed" into place and to take up small errors in the alignment of the bearing. The matrix should be sufficiently soft to wear away very slightly when the bearing is run in, and to leave the hard parts standing in relief. In this way the bearing surface is reduced and the frictional loss is lessened, while the channels between the hard relief provide means of circulating lubricant over the whole working surface.

A sample of phosphor bronze of the composition detailed above is shown in the micrograph, Fig. 1, from which it can be seen how the alloy fulfils the bearing-metal requirements. The microstructure consists of a ground mass α of relatively soft constituent, in which is embedded a network δ of hard material. The α solid solution, which constitutes the matrix in all sand-cast bearing bronzes, contains about 7% tin. The hard material consisting of δ solid solution contains a higher proportion of tin than the α matrix. Along with the δ is also the whole of the phosphorus in the form of copper phosphide. The hard material is shown at a high magnification in Fig. 2, and the δ solid solution, and the copper phosphide Cu_3P can be distinguished.

The α solid solution which forms the matrix of the bronze is comparatively soft. Its Brinell hardness is about 50 to 70, and it possesses considerable ductility. The Brinell hardness of the hard materials—the δ solid solution and the phosphide—are respectively about 220 and 130. By a suitable adjustment of the tin and phosphorus contents of the alloy any proportion of hard material, and, in consequence, any degree of hardness in the alloy as a whole, may be produced. From the point of view of cheapness, it would appear to be desirable to obtain as much as possible of the required hardness by means of phosphorus, and as little as possible by means of expensive tin. There is, however, a serious objection to the hardness produced by phosphorus. Bronzes containing large amounts of phosphorus are generally brittle, and liable to fracture under shock, whilst on the other hand, a much higher degree of hardness may be secured by tin additions without dangerous brittleness. The high tin bronzes, therefore, although more expensive, are much tougher than the high phosphorus alloys.

Adjustment of Tin and Phosphorus Contents

A careful adjustment of the tin and phosphorus contents of a bronze, in accordance with the service that the bearing has to give, without extravagant use of expensive tin, requires a nice metallurgical control of the composition, and, if such control is carried out successfully, important savings from a commercial point of view may result. When considering the choice of a suitable composition, it is primarily necessary to know to what extent the bearing may be subjected to shock and repeated impact stresses. If the working conditions are very severe, then it is necessary to keep the phosphorus low and employ a fairly high tin content. Examples of such highly stressed parts are found in axle bearings and transmission gearings of road transport vehicles, such as lorries and buses, where continual bumping on the road repeatedly subjects the bearing to heavy shocks. For small stationary machinery bearings, which are not liable to such shocks, the phosphorus may be increased, and the tin content lowered. Whatever adjustment is made in the relative proportions of tin and phosphorus, the micro-structure of the alloy should continually be studied, in order that the essential "bearing metal" structure may always be adhered to. Neither must too much soft material, on the one hand, nor too much hard constituents on the other hand, be produced. To retain this essential structure it will be found that in no case will the tin exceed 14%. When the tin is pushed to its upper limit the phosphorus must be kept low. With about 11% tin the phosphorus may be increased to about 0.5%, but if more phosphorus is added, then the tin must be still further lowered until with 1.0% phosphorus—which is the maximum amount desirable in any bearing bronze—the tin content should be no more than 9—10%.

Effect of Other Constituents

Phosphor bronzes invariably contain other elements, either in very small proportions in which they are regarded more or less as impurities, or are added for a definite purpose, and it will be as well to consider the influence of these elements on these alloys.

The best quality phosphor bronzes which are chosen for high duty should generally be as free as possible from metals other than tin, phosphorus, and copper; although, for certain purposes, lead and nickel may sometimes be permitted. Several leading metallurgists question the advantages supposed to be derived from lead additions, but there is no doubt that these alloys have achieved a good deal of popularity for many purposes. The nickel-bearing phosphor bronzes have recently received attention, and their value is generally realised. With the exception of these two metals, lead and nickel, all other metals should be regarded as impurities. Some impurities are, without doubt, seriously injurious, and others are at the best unnecessary. The commonest impurities are zinc, iron, and, in smaller amounts, antimony, arsenic, and also such extraneous inclusions as sand from moulds and scum and slag from the metal.

The effect of lead on the mechanical properties of phosphor bronze is immediately noticed in a reduction of its maximum stress and yield point. The co-efficient of friction and resistance to abrasive wear are in general improved. A simple phosphor bronze, for example, containing 5—10% lead, will retain a perfectly true working surface for long periods, provided that the load is not too heavy. For locomotive slide valves and similar purposes, where a steam-tight joint is required, leaded phosphor bronze is generally chosen. A typical composition would be:—

	%
Tin	10
Lead	7
Phosphorus	1
Copper	82

The lead content of these alloys should never be below 5%, and may be as high as 10%. Smaller amounts of lead bring about no advantages to compensate for the loss of strength due to the lead inclusion. Structurally, lead remains free in bronze as globules of pure metal scattered throughout the alloy, and a micro-section, polished but not etched, clearly shows the lead inclusions. In Fig. 3 is shown the micro-structure of the alloy of the composition given above.

An objectionable feature of lead in phosphor bronze is the difficulty it imposes on the founding of good castings. Lead and phosphorus combine to produce a very fluid slag, which is liable to run with the metal into the moulds, and to leave gritty patches in the castings. These slag inclusions soon cause scoring of bearings and shafting in service, and the replacement rendered necessary may be both costly and inconvenient. If the lead content is too high, it may also segregate into large pools in the castings, and thereby cause bearings to wear unevenly.

The addition of nickel to phosphor bronze for bearings has come into prominence. With about 2% nickel the crystal structure of a normally cast bronze is considerably finer than in a similar bronze nickel free. The distribution of the phosphorus is also affected by the presence of nickel. Whereas, in an ordinary phosphor bronze all the phosphorus is present as copper phosphide, in a nickel phosphor bronze the phosphorus begins to appear as nickel phosphide. Nickel has a greater affinity for phosphorus than has copper, and when sufficient nickel is present the whole of the copper phosphide may be broken down and replaced by nickel phosphide. The practical advantages of nickel phosphor bronzes rest on the relative merits of the two phosphides, coupled with the effect of the smaller grain size and consequent finer dispersion of the hard phosphides.

Nickel phosphor bronzes are more extensively used for gears than for bearings. For this purpose it is usual to add 1—2% nickel to the ordinary bearing bronzes containing about 10% tin. Gears made from these alloys are said to have a greater resistance to wear and to pitting than ordinary phosphor bronze gears. The mechanical properties of such alloys are shown in the following table:—

Composition.			Mechanical Properties.		
Tin.	Nickel.	Phosphorus.	Maximum Stress.	Yield.	Elongation.
% 11 10	% 1 2	% 0.25 0.25	Tons per Sq. In. 17 21	Tons per Sq. In. 14 13	% 3 7

The impurity most liable to be found in a phosphor bronze is zinc. A small quantity of zinc seriously reduces the anti-friction properties, and if present to the extent of about 1% it causes rapid seizing and tearing of bearings which run at more than moderate speeds. For high-speed bearings no more than a trace of zinc should be present in the bronze, and even for less severely worked parts the zinc is best kept down to as low limits as possible.

It is sometimes claimed that the presence of zinc improves the casting properties of phosphor bronze, but such a statement rests entirely on a misconception. When the

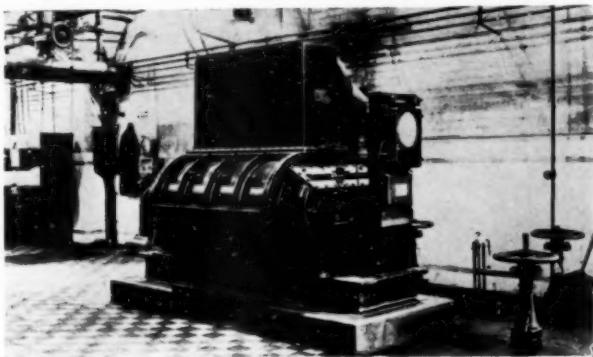
foundry conditions are properly controlled, zinc may be extremely objectionable. If the foundry practice is already thoroughly bad, then zinc may be welcomed as an ally in producing castings which appear superficially improved. When such bearings are put into service, however, rapid failure invariably results. The phosphor bronzes which are used for bearings should, of course, be distinguished from the gun-metals, which contain zinc as an essential constituent, and which are used under entirely different conditions from phosphor bronzes.

Most cast phosphor bronzes contain a small amount of iron, unless very special precautions are taken towards its exclusion. The use of iron stirrers in the foundry, the contamination of scrap metal with chips of steel, and so on, are likely to leave traces of iron in the alloy. This iron remains undissolved as tiny inclusions, which are harder than the remainder of the alloy and are liable to score the shafting running in such bearings. The iron content of these alloys should, therefore, be kept as low as possible.

Measurement of Blast-Furnace Gas

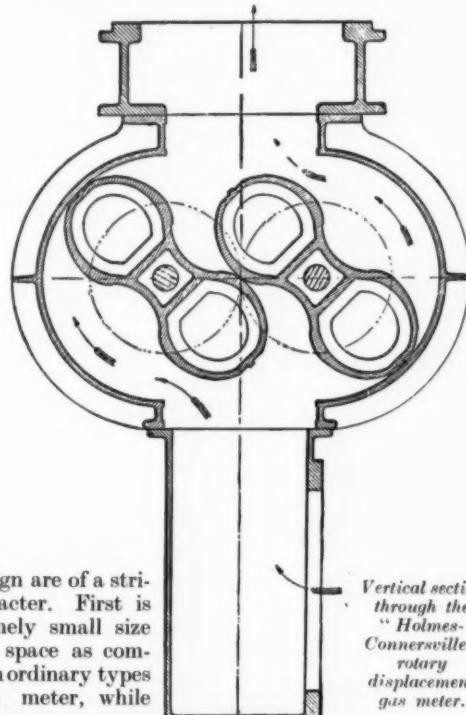
FOR the continuous measurement of blast-furnace gas, including coke-oven gas, producer gas and air, of great value is the "Holmes-Connersville" patent positive displacement rotary meter. Essentially the principle may be described as that of a modified "Roots" blower, consisting in the use of two cast-iron impellers of special shape, which always inter-engage with one another without actually touching, being fixed on separate parallel shafts, connected by gearing at each end, and are driven round by the gas pressure, rotating in opposite directions at a speed corresponding to the flow of gas.

The arrangement is contained within an outer cast-iron casing provided with heavy ribs, split longitudinally at the centre, and bolted together, with the inner surface of which the impellers also constantly inter-engage, as well as with each other. The workmanship is such that the impellers have a clearance between them at all points of less than 0.002 in. (two thousandth), and the same applies to that between the impellers and the casing.



"Holmes-Connersville" rotary displacement gas meters of 7,800,000 cubic feet per 24 hours capacity measuring coke-oven gas at the Smithy Wood coke ovens, Chapel Town, Sheffield.

Since the impellers are formed of true mathematical curves, the displacement can easily be calculated, and also if necessary the reading of the meter checked by the use of actual test gasholders of known capacity. Readings are given by a counter mechanism, being the shaft revolutions expressed as gas volume, whilst a continuous record of the temperature pressure and volume of the gas passed per hour by means of pens on a chart is easily included. The accuracy is extremely high, being within the limits of plus or minus 1% from one-tenth up to 1½—twice the normal capacity—depending on the size, and the other advantages



of the design are of a striking character. First is the extremely small size and floor space as compared with ordinary types of station meter, while almost any gas pressure can be taken the standard meters being suitable for up to 10 lb. per sq. in. and a high-pressure modification up to 300 lb. Further, the accuracy is independent of variation in specific gravity, varying rate of flow, moisture content, and impurities.

These rotary displacement meters, manufactured by W. C. Holmes and Co., Ltd., of Huddersfield, are available in a wide range of sizes, from 8,000 to 1,250,000 cu. ft. per hour normal gas capacity. For example, the smallest size has a 4-in. diameter inlet and outlet pipe, with impellers 12 in. long and gears 4-in. pitch diameter, weighing 500 lb., and taking up to 16,000 cu. ft. of gas per hour as a maximum overload. The floor space is only 16 in. × 33 in., and the height 22 in., while the differential pressure loss is $\frac{1}{2}$ in. W.G. As regards the largest size, the pipes are 30 in. diameter, impellers 96 in. long, and gears 32 in. pitch diameter, weighing 40,700 lbs. (about 18 tons), occupying a floor space of 94 in. × 167 in. and having a height of 128 in., the pressure loss being approximately 1 in. W.G. when passing the normal-rated volume of 1,250,000 cu. ft. of gas per hour.

Reviews of Current Literature

The Outline of Iron and Steel

Man's acquaintance with iron can be traced back through at least 50 centuries, but only in the past fifty or sixty years or so has he begun systematically to apply science to the manufacture of iron and steel, and during this latter period more has been accomplished than in all the centuries which preceded it. To-day much interest is taken in the iron and steel industry because these materials are basic, that is, they are essential for the maintenance and development of social conditions and civilisation itself. Interest is shown in iron and steel structures of various kinds, in machines which involve the use of iron and steel, and in manufacturing processes. That operations in iron and steel works have an interest to the layman is indicated by the display of films at public cinema halls showing these operations.

To the layman the technical terms which are associated with the operations are difficult to understand, and in this interesting book a brief outline of the industry is given which he can readily grasp. The author has considered it necessary to deal somewhat fully with origins, so that current conceptions may be more completely understood, and future developments visualised. An effort has been made to give due credit to localities and countries in proportion to their influence on the development of the industry. Some of the early chapters indicate the fundamental lines on which the author presents the subject: the early production of iron by mankind, the origin of modern conceptions, and the beginnings of modern steel manufacture, give the layman the right angle from which to obtain an outline of the various processes of manufacture carried out to-day.

Although this book has been written more especially for the layman or inquiring amateur and possibly students, as the author points out in his preface, many engineers will find the descriptive matter of absorbing interest. It provides instruction not easily obtained from the more technical books on the subject because technical considerations involve so many factors of scientific knowledge concerning not only the actual material produced, but also the materials used in production. The text matter is admirably presented and the book contains some excellent illustrations. It is recommended not only to the layman, but to those who are actually engaged in some sections of the industry as a convenient and readily assimilated outline of the iron and steel industry which is interesting as well as informative.

By Archibald Allison: published by H. F. and G. Witherby, Ltd., 326, High Holborn, London, W.C.1. Price, 6s. net.

Chromium Plating

As a commercial proposition chromium plating was practically unknown about 10 years ago, but in the laboratory it had been of academic interest for a long time. One of the most striking features of chromium plating is the immense variety of trades into which it has been introduced and found to be of extreme value. Mechanical, electrical, structural, and civil engineering have all found the hardness of the chromium plating to be of great service, because of its resistance to abrasion and erosion. The cotton, wool, silk, artificial silk, and general textile industries have recognised its property of high resistance to corrosion, from which they usually suffer. Glass manufacturers, and users of all kinds of dies, have adopted the process to their great advantage.

The introduction of chromium plating occurred at a time when rapid development of the motor-car industry was taking place which considerably increased the scope for plated finishes. These developments stimulated a closer investigation into the properties of electrodeposits, with a view to placing the control of the electroplating process on a scientific basis. Thus commercial chromium plating was developed at a time when the results of careful

investigations on electrodepositing were being applied in practice and the work discussed in this book is primarily concerned with an investigation on chromium plating with special reference to its use in the automobile industry.

Much of the information on chromium plating is widely scattered, and its implications are not generally appreciated. This book fulfils a useful purpose in providing a correlation between the results of research and of practice. The original German edition, which comprised a report issued by the Staatliches Materialprüfungsamt in 1934, has been amplified in this English translation, and it constitutes a valuable contribution to the knowledge of the properties of typical coatings as produced commercially. The translator has widened its scope by the inclusion of notes referring to electroplating practice and to work, especially of British and American origin, which was not mentioned in the authors'.

The book consists essentially of a description and discussion of results of an extensive examination of typical plated parts of German motor-cars. Fifty-nine representative components, made of steel, brass, bronze, zinc-base die-castings and aluminium castings, were obtained from 10 German plating firms; three parts of a French and three of an American car were also examined. Five components only were finished with nickel, the remainder being chromium plated. The components, together with specially prepared samples of the various materials in sheet form, also plated under commercial conditions, were examined for thickness of coating, adhesion and capacity for deformation, hardness and wear resistance, resistance to variations of temperature, porosity, and behaviour in outdoor exposure, salt spray and immersion in salt water. The description and discussion of results makes this book, in many ways, an important contribution to the advancement of chromium plating.

An informative introductory chapter by Mr. A. W. Hothersall, M.Sc., deals with electroplating practice and the properties of chromium and nickel coatings. By Professor Dr. Ing. O. Bauer, Professor H. Arndt and Dr. Ing. W. Krause; translated from the German by E. W. Parker; published by Edward Arnold and Co., 41-43, Maddox Street, London, W.1. Price, 25s. net.

Pearlitic Malleable Cast Iron

A symposium on the above subject was recently presented at a meeting sponsored by the American Society for Testing Materials: Cleveland District Committee. This symposium consists of material assembled from various sources and contributed by individuals interested in pearlitic malleable iron, which term is used because it is considered to be the best compromise for materials cast as white cast iron and subsequently treated to retain significant amounts of combined carbon. The American Foundrymen's Association co-operated in assembling the symposium.

The introduction details the scope of the discussion with some historical information. In describing a systematic sub-division of the pearlitic malleables, it is stated that the prevailing opinion of interested persons in the A.F.A. is that any material which starts out as white cast iron and is subsequently heat treated to produce graphitisation is to be called pearlitic malleable if the graphitisation is purposely terminated when sufficient combined carbon remains to significantly affect the properties of the product.

Pearlitic malleable cast iron seems to have a large potential field due to wide variation of physical properties possible by heat treatment, and is being sold under several trade names. The section of the symposium on Producers' Data gives information on typical physical properties, treatment and uses of such pearlitic malleables as high silicon, copper-bearing high manganese, spheroidized, bull's-eye, short-cycle and others.

Copies of the symposium, comprising 32 pages, can be obtained from A.S.T.M. Headquarters, 260 S. Broad St., Philadelphia, or through the American Foundrymen's Association, at 60 cents each; or for 10 or more copies, 45 cents each.

The Application of X-Rays to Metallurgy

By C. HUBERT PLANT

This is the first of a short series of articles designed to familiarise the average worker with the working of X-ray apparatus and to show its application to metallurgy in a form which can readily be understood. X-rays have proved themselves to be of great fundamental value in the progress of knowledge of the structure of metals and their importance industrially is gradually being appreciated in the normal routine of manufacture.

ANALYSIS of metals, both ferrous and non-ferrous, by means of X-rays is becoming of greater importance to metallurgists generally, and is being used more widely in works laboratories in the United States and on the Continent, though with some exceptions the importance of this branch of metallurgical practice does not appear yet to have found much favour in this country apart from its use in connection with the work of Research Associations, Universities, etc. This may be, and undoubtedly is, due to some extent to the first cost of installation of a complete X-ray apparatus, but apart from this there is undoubtedly an opinion in the minds of a great number of metallurgists that X-ray analysis is something so abstruse, something so fraught with elaborate and highly theoretical mathematics, that it is quite out of the reach of the majority and can only be appreciated or understood by advanced physicists or mathematicians. X-rays have proved themselves to be of such fundamental value in the progress of our knowledge of the more intricate directions of research into the ultimate constitution of metals, alloys and matter generally that there is some excuse for this opinion, and this has been emphasised by the fact already mentioned that it is those who are concerned with the higher branches of research who have realised the importance of the use of X-rays. Their results, proclaimed either by lectures or published in scientific journals, have added to this idea, and the author has been present at lectures upon subjects directly connected with X-ray analysis which have been so highly theoretical in character that he did not feel surprised that some members of the audience became so uninterested that they left before the lecture was ended.

All this is very unfortunate, because, as this thesis will endeavour to show, a knowledge of X-rays, of the practical working of X-ray apparatus and of the results which can be obtained, can be known and understood by anyone without a knowledge of the higher branches of physics or without having to understand analytical mathematics, of such an intricate nature as Heisenberg's equation. Moreover, the really practical results of X-ray analysis are all obtained without these abstruse means. By practical results is here meant results which will not only aid the usual chemical analyses, micro examination and mechanical tests of metals, but will, at least in the author's opinions, upend them if carried to their logical conclusions. Admittedly, the more highly theoretical results obtained by our research workers, and some marvellous information has been gained, must eventually also be of assistance to industry, but as Professor Hanson of Birmingham University pointed out in a lecture recently, while these results may at the present time appear difficult to understand, there would be less difficulty in it, for the younger men whose training was now in line with the newer ideas, and matters such as these would in the future become part of the usual course in physical metallurgy.

Having thus outlined the general reasons for this thesis, it is intended to endeavour to lead the reader through the various stages of thought and experiment which has led to the present knowledge of X-ray analysis and its practical value.

Development of X-Rays

To do this, it will be necessary to take our minds back to about the year 1859. It was in this year that a physicist, Julius Plücker (born 1801, died 1868), while following up some of Faraday's work on electromagnetism, discovered that if an electric charge was passed through a tube which had been partially exhausted, it began to glow with a certain pink luminosity. Whether Plücker realised the meaning of this glow is not certain, but it is certain that in the year 1886 Sir William Crookes studied this phenomenon, but exhausted the tube through which he passed the electric discharge to a much greater extent than did Julius Plücker, with surprising results. When the pressure inside the tube was only a few hundred thousandths of an atmosphere, the glow noted by Plücker became very faint, but the glass walls opposite to the cathode (the negative electrode) began

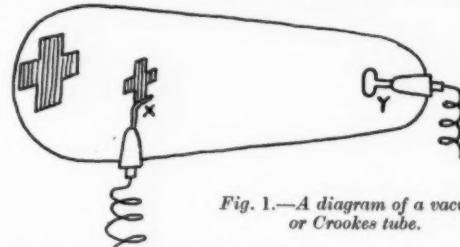


Fig. 1.—A diagram of a vacuum or Crookes tube.

to glow with a greenish fluorescence, and by putting into the tube some substance which casts a shadow, it could be shown that this fluorescence was caused by something which was being shot out from the cathode. Sir William Crookes said they were "streams of negatively electrified particles projected normally from the cathode with great velocity." He termed them cathode rays without realising their true constitution, but in 1895 A. Lorentz formulated the electron theory, and it was accepted that these rays were electrons, or particles of negatively charged electricity. For many years these vacuum tubes, or Crookes tubes as they have been termed, were the electrical playthings of the laboratory and popular lecture room, but recent discoveries have raised them from the rank of scientific toys to the rank of pieces of apparatus whereby have been made some of the greatest discoveries in physical knowledge that the last generation or two have seen.

A diagram of one of these tubes is shown in Fig. I. The anode is shown at X, the cathode at Y. On the former has been super-imposed a thin metal plate of cross shape, which throws a shadow on the glass end of the tube when the electric discharge is passed through and the cathode rays are projected from the cathode towards the anode.

Anticipating events a little in terms of time, Sir J. J. Thomson in 1904 devoted time and energy to these cathode rays and showed that a beam of these rays could be deflected in its course either by the aid of a magnet or by means of an electric field between the charged plates of a condenser. A diagrammatic sketch of his apparatus is shown in Fig. II. The beam of particles shot out from the cathode A passed through slots in the anode B, and under the influence of the magnetic field induced at X

described the curve shown. From measurements of deviations caused in this manner he was able to estimate the velocity and also the ratio e/m between the charge e and the mass m of the particles. He found that the velocity varied with the potential at the cathode and could be as much as 30,000 m.p.s., or about one-sixth the velocity of light. The ratio e/m always had the same value, and he computed that the mass of these particles was $1/1835$ of the mass of the hydrogen atom. He assumed, and his assumption has often been confirmed, that these electrons are free atoms of negative electricity, and are a universal constituent of all atoms. It would be possible here to launch into intricate mathematical theories to prove that Sir J. J. Thomson's assumption was not correct, that the electron is not a discrete particle of negative electricity, but that it is rather a bundle of energy, but this would be stepping right outside the promise given in the introduction to this thesis.

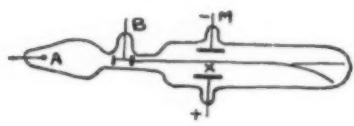


Fig. 2.—A sketch of the apparatus developed by Sir J. J. Thomson.

To continue, in the same year that Lorentz gave the world his far-reaching electron theory, Philip von Lenard, an Austrian pupil of Hertz, following out a suggestion by Hertz in regard to cathode rays, observed what seemed to be the passing of cathode rays through a thin piece of aluminium which formed part of the containing wall of his vacuum tube. No further comment need be made about these Lenard rays themselves, but later that year Wilhelm Konrad von Röntgen was studying the properties of cathode and Lenard rays by means of highly-exhausted tubes, in the vicinity of which he had stored some very carefully protected photographic plates. Having occasion to use these, he was surprised to notice that they had all the appearance he would have expected them to have had they been exposed. He naturally concluded that this was important and, assuming that the cause of this effect was their proximity to the exhausted tubes, he commenced experimenting, and quickly found his assumption to be correct. Proceeding further, he became certain—that something was emanating from the vacuum tubes, so placed some phosphorescent substance on a screen near to one of them. His increased interest can be imagined when he found that the phosphorescent substance glowed brilliantly. Further experimenting produced still more surprising results, for he found that this mysterious influence was obstructed by some substances, but not nearly to the same extent by others. For instance, a thick piece of metal cast a sharp shadow on the phosphorescent screen, but wood or aluminium, normally opaque to light, cast only slight shadows, whilst if a human hand were placed between the tube and the screen a shadow of the bones was sharply produced, but only a slight shadow was obtained of the flesh and muscle. Röntgen naturally concluded that he had discovered some hitherto unknown form of radiation. This radiation, or the constituents thereof, was termed Röntgen rays, and subsequently X-rays.

Radiation

It will now be as well to digress slightly and consider radiation in general. It will not be necessary to discuss the various arguments as to the constitution of radiation, and for the purposes of the subject under discussion it will be assumed that Clerk-Maxwell's electromagnetic theory is correct in every way, otherwise it will be necessary to consider Planck's Quantum Theory, the work of Einstein, and subsequently of other mathematicians such as Heisen-

berg and, as already explained, the subject would then involve such abstruse ideas as to place it right out of the practical character which it is desired to maintain. All radiation, therefore, consists of electro-magnetic waves, which the physicist has divided up into different series according to the wavelengths and the frequency. It is a well-known fact that the velocity of light is 186,000 m.p.s., so that the wavelength is the velocity divided by the frequency (cycles per second), or the frequency is the velocity divided by the wavelength. Although the wavelengths or frequencies of electromagnetic waves form a continuous series from zero to infinity, names have been applied to groups or ranges of them. These names have arisen in various ways, but it should be understood that there is no definite division between groups, and that the only fundamental difference in any case is wavelength or frequency. The various radiations have different properties which are the result of their different wavelength. It is helpful in considering any form of radiation to point out the connection between the various groups, as a better picture is then obtained as to the position of any one range or group. Commencing, therefore, with the longest known waves, the first in order are the waves used in wireless transmission, and they range from 10,000 to about 100 ft. in length. Next come the so-called Hertzian waves, named after Heinrich Hertz, who first experimented with waves of this length, namely, from 100 ft. to 1 ft. in length. The radiation range now enters the infra-red region, which extends to waves of only about 76×10^6 cm., after which comes the visible spectrum, passing through the reds to the violet according to the order which is so well-known in the rainbow. At the violet end of the spectrum the waves are of the order of 39×10^6 cm., after which follows the ultra-violet range down to 10^9 cm., in length. These waves are exceedingly short and their effects are well-known, although the human eye cannot, of course, detect them, while the photographic plate can, down to certain wavelengths. Such was the wavelength range as known in 1895, when Röntgen was carrying on his far-reaching experiments.

To return now to the actual subject of X-rays, Röntgen having realised that the rays which bore his name were some definite entity, he set about attempting to discover their real constitution. He was able to prove that they travelled in straight lines, and that in passing from one medium to another they underwent no refraction. They were also unaffected by a magnet; but for many years the real nature of the rays could not be proved. Röntgen thought it probable that the rays were not material particles, nor longitudinal waves in the so-called ether, but consisted of some form of transverse disturbance of the ether. If this was so, however, the waves should be capable of polarisation, and this did not appear possible by any means in his power. Strutt, the son of Lord Rayleigh, succeeded in polarising these rays, thus proving that they were, to some extent at any rate, of the same order of radiation as light rays, and this being the case they must of necessity be electro-magnetic radiations.

Diffraction Grating

By ruling fine lines, many thousand to the inch, a device known as a diffraction grating is obtained, which diffracts light and other radiations in such manner that by simple mathematics and easy measurements wavelengths can be determined. Nevertheless, all attempts made to determine the wavelength of Röntgen rays by this means failed, and up to the year 1912 these rays were still something of a problem. It was obvious that if they were identical with light their wavelength was extremely short, and their frequency excessively high, since they could not be diffracted by any of the ordinary means used for diffracting light.

Before entering into the final discussion as to the constitution of these rays, it is necessary to consider shortly the meaning of and reason for the diffraction of rays. Light travelling down a passage illuminates only the wall opposite the door—the waves of light are infinitesimally

small compared with the width of the doorway. If, however, a doorway is made of width not greater than a few wavelengths of light, then the light will spread out in the same way that sound waves will spread, and the light is said to be diffracted. If, for instance, a candle flame is observed through an exceedingly narrow slit—assuming the candle to be placed in front of a dark screen, the direct flame will be observed, but on either side of it will be seen a series of light and dark bands, which are termed diffraction bands. The dark bands are produced where the crest of one wave of light is superimposed upon the trough of another wave, while the bright bands are the superimposition of waves of similar phase, crest on crest, or trough on trough. A rough, ill-defined result such as this is, however, impossible for the purpose of measuring wavelengths. To effect this the diffraction bands must of necessity appear as fine lines, because the source of light or other rays which it is desired to measure will be much narrower than the flame of a candle. This result can only be obtained by the use of several hundreds or thousands of narrow apertures, side by side, close together, parallel to one another and separated in a particular manner. Fraunhofer was the first to make a diffraction grating on this principle, which he did in 1821, but Rowland, of Baltimore, constructed some of the most perfect gratings ever made, and he took advantage of the fact that light or rays reflected from a polished-plane mirror upon which lines very finely divided have been ruled will give better results than by passing the rays through fine apertures. Rowland was able to produce diffraction gratings upon which lines were ruled so close together that there were 40,000 lines to the inch.

The lateral diffraction bands produced from the candle have been mentioned. By the use of a diffraction grating these bands are produced in the form of a spectrum, analogous to the spectrum produced by the prismatic spectroscope, used mainly for astronomical purposes.

Diffracting X-Rays

It has been said that the wavelength of X-rays was so extremely short that no means of diffracting them in order to measure the wavelength could be found. In the year 1912, Professor von Laue attacked the still unsolved problem as to whether X-rays were identical with light rays. It will be remembered that Strutt had more or less proved that they must be electro-magnetic radiations, but this did not prove conclusively that they were exactly the same type of radiation as light rays. However, von Laue, by a brilliant piece of mathematical analysis proved quite conclusively that what had been suggested was a fact, and went further by suggesting an experiment which, if it were successful, would show practically what he had proved theoretically. He suggested the use of a crystal as the diffraction medium—no diffraction grating could be ruled finely enough to produce diffraction of such short waves, and he thought a crystal, because of the regularity of its structure, and the distance apart of its constituent atoms, would function perfectly in this respect. He reasoned that if X-rays were identical with light, their waves would be something like 10,000 times shorter than the waves of light. It has been stated already that the violet end of the visible spectrum has waves of about 39×10^{-8} cm., which is 0.000036 cm., so that the wavelength of X-rays would be of the order of 1×10^{-9} cm. or 0.000000001 cm. In a diffraction grating ruled 40,000 lines to the inch, it follows that there would be approximately 16,000 lines per centimetre. The atoms in a crystal cell, or in other words the length of the side of a crystal cell, is in the region of one Angström unit, that is, one hundred-millionth of a centimetre. Taking Laue's prediction that the wavelength of X-rays was 10,000 times shorter than ordinary light rays, it was fair to assume that a diffraction grating was required equal to 160,000,000 lines per centimetre, so that the distance between each line would be approximately the length of a side of a crystal cell. Laue therefore suggested using a crystal as a diffraction grating for X-rays, with complete success, thus proving conclusively that X-rays

were a form of radiation exactly the same in form if not in degree as the radiations which are recognised as light, heat, etc. The experiment suggested by von Laue was carried out in the laboratory of the University at Munich by two physicists, Friedrich and Knipping. A fine pencil of X-rays was passed through a crystal and allowed to fall upon a photographic plate. After some hours' exposure, the plate was developed and there appeared a symmetrical arrangement of spots centred about an intense over-exposed spot, which was due to the action of the direct pencil of rays. Fig. 3. gives an indication of what this result looked like. The regular arrangement of small spots surrounding the central spot are due to those components of the rays which had been diffracted by the atom planes in the crystal.

The importance of the information thus obtained was quickly realised by two great physicists in this country, Sir William Bragg and his son Professor W. L. Bragg. They realised that the arrangement of spots provided an indication of the arrangement of the atom planes within the crystal, and hence gave an indication of the structure of the crystal itself. They pursued the matter exhaustively, and were able to enunciate an equation which would enable the structure of the crystal to be ascertained from the observed data. They went further, however, and assumed that as X-rays were identical with light waves, they should be capable of reflection by the regular atom planes in the crystal. This reflection would, however, not be the same as the reflection of light by a mirror, but would be a form of reflection from within the crystal. Their assumption was that a train of X-ray waves, having impinged upon an electron (the negative particle surrounding the nucleus of the atom), would cause it to vibrate and it would thereupon emit a train of waves having exactly the same frequency as the train of waves causing the vibration. Obviously, as electrons are part and parcel of the atom, this would be akin to reflection from the atom itself. Upon this conclusion and its results the whole of the principles of X-ray analysis have been built.

Thus was the general nature and constitution of X-rays arrived at, and in the next Section of this series the means by which these theories and discoveries have been put to practical use will be described and explained.

The Flin Flon Mine

The Flin Flon ore-body was once deemed to be so complex and difficult from the metallurgical standpoint, that many people doubted whether it would ever be possible economically to recover its metal content. The first tests, carried on through a period of two years, appeared to confirm the general pessimism. The Hudson Bay Mining and Smelting Co., Ltd., spent more than \$1,000,000 before noticeable results appeared. More than \$25,000,000 was then invested, some of which was contributed by Canadians, but most coming from the United States. This complex, ore, however, is now yielding seven different metals—copper, zinc, gold, silver, cadmium, selenium and tellurium. The recoverable content of none of these metals runs to less than \$3 per ton, and last year the total average recovery was \$6.50 per ton.

Beginning commercial production with an ore reserve of 18,000,000 tons, development during the past six years has added another 13,000,000 tons for, after treating 7,000,000 tons since 1930, the mine at the end of last year was able to show an ore reserve of over 24,000,000 tons of higher grade than at the beginning. Production at the present time is at the rate of 50,000,000 lb. of copper, 60,000,000 lb. of zinc, 100,000 oz. of gold and over 1,000,000 oz. of silver annually. The extraction percentage has steadily risen.

The British Aluminium Co., Ltd. have recently issued two useful booklets, one dealing with aluminium sections and the other with aluminium sheet, strip and circles. These will assist users in the selection of shapes or types of sheet available. Copies are available from the British Aluminium Co., Ltd., Adelaide House, King William Street, London, E.C. 4.

Problems Relating to Tin

SEVERAL publications have been issued with the object of assisting consumers in overcoming technical difficulties and problems relating to tin. Four of the more recent of these publications are discussed briefly in the following notes:—

Corrosion of Tin and Other Metals by Insulating Oils

Researches by P. J. Haringhuizen and D. A. Was, at Utrecht, on the above subject, are described in publication Series A, No. 35. By volatilizing tin, lead or copper from tungsten filaments in vacuo, extremely thin films of each metal were deposited upon squares of mirror glass. By a series of measurements the thickness of the films was related to the amount of light transmitted by them. This relationship allowed the thinning of the films due to corrosion in insulating oils to be determined. From the experiments it is concluded that the metals build up a protective film of reaction products on their surfaces. In the case of copper this film is continuously destroyed, but tin and lead have a durable resistant film, and the diffusion through this film controls the corrosion. Experiments with different oils showed that the velocity of corrosion is not related to the concentration of the acids formed by the deterioration of the oils. The results have been expressed by an experimental formula, for which an attempt is made to provide a theoretical basis.

The Attack on Mild Steels by Weak Acid Metals

In researches by T. P. Hoar, M.A., Ph.D., the attack by citric acid, with and without citrate buffers, was studied gravimetrically and electro-chemically under simple conditions, the results being correlated with the chemical and metallographic analysis of each material. The effects of sulphur, of tin, and of other metal ions in the corroding media have also been investigated. The main result established is that sulphur in steel has a pronounced accelerating effect under these conditions, but that this acceleration is entirely counteracted by the presence of approximately twice as much copper as sulphur in the metal and is partially suppressed by small amounts of tin ions in the corroding media. A simple yet comprehensive theory is developed to account for these and other phenomena, and possible applications to practice are indicated.

De-tinning to Expose the Tin-iron Alloy Layer in Tinplate

In studying the continuity, structure and behaviour on deformation of the alloy layer on tinplate, it is necessary to remove the coating of tin without attacking the underlying layer of tin-iron alloy or any exposed steel. This may be done by means of sodium plumbite or aqua regia, but in addition a new electrolytic method has now been devised by A. W. Hothersall and W. N. Bradshaw. They describe their experiments with these methods and they have investigated the thickness, appearance and continuity of the alloy layer on tinplate of various grades. The electrolytic method consists in anodic treatment in 5% sodium hydroxide solution at 30° C. under a controlled potential difference, and takes from 10-20 minutes.

It is noted that the thickness of the alloy layer agrees closely with that found by other workers for different grades of tinplate, but if the plates have heavier coatings than usual, as a result of being re-immersed in molten tin, there is a considerable variation in the thickness of the alloy layer, which indicates that the time of re-immersion allowed in practice is very variable.

Causes of Porosity in Tinplate

Pores or discontinuities in hot-dipped tin-coatings on steel are one of the chief problems of tinplate manufacture. As a preliminary to the study of their causes, A. W. Hothersall and J. C. Prytherch have examined tinplate of various grades and have established a connection between the location of the pores and surface peculiarities and

imperfections such as scruff bands and grease marks. In tinplate withdrawn from the top of the grease-pot without passing through the cleaning or polishing rolls 75% of the pores were located in scruff bands and grease marks. With tinplates carrying more than 3 lb. of tin per basis box, there were no scruff bands, and the largest grease marks, grouped in periodic bands across the sheet, contained practically all the pores except those which were associated with scratches. The scruff bands appear to be caused by chatter of the grease-pot rolls, or by slight periodic slip between the roll and the tinplate surfaces. These results are described, and the authors conclude with some suggestions as to the reasons for the concentration of the pores in these surface peculiarities.

Copies of any of the above publications may be obtained free of charge from the International Tin Research and Development Council, Manfield House, 378, Strand, London, W.C. 2.

Utilising Blast Furnace Slag

IN the sand-lime brick process, of great interest also for the utilisation of blast-furnace slag, the efficient slaking of lime to produce a product that is completely slaked, with no trace of live lime (CaO) and no appreciable excess of moisture, is a much more difficult proposition than is generally imagined. Although lime has a great avidity for water, it is surprising to what an extent a mass of slaked lime will still retain traces of live lime. In this connection plant recently supplied by Sutcliffe Speakman and Co., Ltd., of Leigh (Lancs.), has a production of 600,000 sand-lime bricks per week, and represents the latest scientific principles.

Essentially the process consists in mixing sand (or equivalent material) with slaked lime, the average composition being 85% sand, 8% of good fat lime, and 7% water in combination, although the figures depend upon the circumstances, including quality of the lime. This mixture is then formed into brick shapes, which are heated by direct high pressure steam in horizontal steel cylinders or autoclaves, generally 30 ft. 0 in.-70 ft. 0 in. long and 6 ft. 0 in.-6 ft. 6 in. diameter, for say 8-12 hours, at 125-165 lb. per sq. in. The main chemical reaction consists in the formation of calcium silicates by interaction between the slaked lime and the sand, which bind the shapes into intensely hard and dense bricks like natural stone, with a smooth surface and dead straight edges. At Redhill also rod mills are used after the silo to give a still further degree of mixing and increase the density and crushing strain of the bricks.

Much the most efficient method of working is to pulverise the live lime and then mix in the required proportion with the sand, the product being then allowed to lie in silos for at least 24 hours. Slaking results from the natural moisture in the sand and is most effective, no trace of live lime being present.

If the lime is slaked separately another serious trouble is varying moisture of the sand. Thus in rainy weather sand contains much more moisture than in dry weather, and wet sand of this description mixed with slaked lime does not give anything like the same good results in brick making as when the sand has the normal small and uniform moisture content. Under these circumstances without the silo system it is necessary to wait for drier weather before the mixing is carried out, since the sand cannot be dried artificially as a practical proposition because of the cost.

In general it is only in rare and exceptional cases that a hydrated lime plant can work continuously day in and day out, for the manufacture of sand-lime bricks under the climatic conditions that obtain in Great Britain. The silo system is much more suited to the climate of this and many other countries, enabling the manufacture to be independent of weather conditions, while at the same time also ensuring more scientific control of the mixture ready for the presses.

Correspondence

Estimation of Free Cyanide in Cadmium Plating Solutions

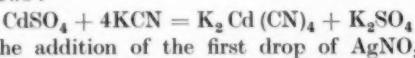
Sir.—In your April, 1934 issue Mr. Halls deals with the analytical control of cadmium electro-plating solutions. We have, however, experienced difficulties in estimating free cyanide in cadmium plating solutions. Repeated estimations of free cyanide failed to give reproducible results, and the following experiments were carried out to determine the reason for the wide variations.

We would appreciate Mr. Halls' comments and criticisms of the methods adopted. If our results are confirmed it would seem that *total* cyanide will have to be determined each time, and calculation made of the free cyanide.

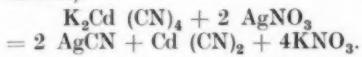
METHOD.

Take 10 ccs. of solution and dilute to 40 ccs. titrate with N/10 AgNO_3 , the end-point being determined by the first formation of permanent turbidity.

Theoretically the reaction between CdSO_4 and KCN is as follows :—



Also the addition of the first drop of AgNO_3 to the double cyanide should give an immediate ppt. (if the method is correct).



EXPERIMENTAL RESULTS.

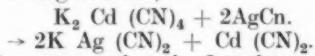
	N/10 CdSO_4 ccs.	N/10 KCN. ccs.	AgNO ₃ Required.	
			Theoretical.	Actual.
(1)	10	10	0	5.8
(2)	10	4.2	—	0.6
(3)	10	20	10	14.8

The second titration should not have required any AgNO_3 , according to the first result.

THEORETICAL CONSIDERATIONS ON ABOVE.

The reaction between the double cyanide and silver nitrate is probably not quantitative due to the partial solubility of $\text{Cd}(\text{CN})_2$ in water (17.0 grms. per litre at 15° C.).

Again, the silver cyanide, while insoluble in water, was found to be soluble in double cadmium cyanide (probably due to the following reaction) :—



It would thus appear that the first drop of silver nitrate would not give a permanent ppt.

EFFECT OF NaOH ON REACTION.

Since plating solutions usually contain NaOH, the addition of this was tried out to determine the effect.

N/10 CaSO_4 [ccs.]	N/10 KCN. [ccs.]	N/3 NaOH. ccs.	AgNO ₃ Required. ccs.
10	10	0	5.8
10	10	1	2.6
10	10	2	2.2
10	10	5	1.7
10	10	10	0.7
10	10	50*	0

* Equals approximately 10 oz./gallon NaOH.

THEORETICAL CONSIDERATIONS ON ABOVE.

The probable reason for the effect on NaOH is shown by the following reaction :—



Since the $\text{Cd}(\text{OH})_2$ is practically insoluble (0.0026 grms. per litre at 25° C.) the addition of increasing amounts of NaOH would make the reaction between the double cyanide and silver nitrate more quantitative.

(N.B.—The presence of NaOH does not give a well-defined end-point, as ppt. is flocculent and practically colourless.)

EXPERIMENTS ON "SYNTHETIC" PLATING SOLUTIONS.

Synthetic plating solutions were made up as follows :—

Cadmium as double cyanide. Ozs./gall.	Free KCN. Ozs./gall.	Na_2CO_3 . Ozs./gall.	NaOH. Ozs./gall.	Free KCN determined by AgNO_3 . Ozs./gall.
3	7	4	1	7.76
3	7	16	4	7.58
3	0	16	4	0.76*

* When solution was diluted to 250 instead of 50 ccs., the reading gave 1.36 oz. free KCN.

The presence of 4 oz./gall. of NaOH is evidently not sufficient. (See Table II.)

The average plating solution contains approximately 20 oz./gall.

Yours etc.,
J. DAWSON.

Criticisms of Method of Determining Free Cyanide in Cadmium Plating Solutions

Sir.—The criticisms raised by the querist have been carefully examined, and the following considered reply is given after a re-examination of the original data upon which the methods were formulated, a new search of available literature, and further experimental work along lines pertinent to the criticisms, have been made.

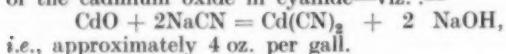
While the practical difficulties encountered by the querist are fully appreciated, the deductions do not appear to be entirely substantiated, and it is still considered that the analytical procedure as laid down originally is sound.

The only other published matter appertaining to free cyanide determination in cadmium solutions that could be traced through metallurgical abstracts is that included in "The Control of Electrodepositing Solutions—No. XIV, The Cadmium Solution," by Samuel Field, *Metal Industry*, 1933, page 309. Field is regarded as something of an authority on these matters, and, for free cyanide he, too, quotes a direct titration with silver nitrate. He stresses that the end point is rather more difficult to detect than is usual with this type of titration, and is rather likely to be overlooked. This is due to the fine, transparent nature of the precipitate rather than one conducive to turbidity. Field recommends an approximate first test with vigorous shaking to promote flocculation. He adds that the presence of potassium iodide is no advantage, although some workers find this helpful, as it imparts a yellowish tinge to an otherwise colourless precipitate.

The methods given in the April, 1934, issue of *Metallurgia* were presented, because it was felt that cadmium solutions were the most difficult of plating solutions rapidly to analyse in routine, yet they, more than any, required control in this manner, and again no data had been published on the matter when research was started to formulate the methods. They were derived from a study of various methods of determining the constituents involved separately, and present together in various proportions to cover the range most likely to be encountered in cadmium-plating solutions in practice. The solution for which it has been used to control has the following nominal composition :—

Sodium cyanide	...	...	...	...	14 oz.
Cadmium oxide	...	...	...	...	6 oz.
Dextrine	...	...	...	...	0.5 oz.
Water	...	...	...	...	1 gall.

It is to be noted that the caustic soda content in this solution is relatively high, being formed in the dissolution of the cadmium oxide in cyanide—viz.:-



VOLUMES ALL IN CCS.

Test.	N 5CdSO ₄	N 10 KCN.	Alkalinity.	N/10 Silver Nitrate.	
				Theo- retical.	Actual.
1	10	10	Slightly acid	Ni	0.05
2	10	25	" "	Nil.	0.7
3	10	30	" "	Nil	1.4
4	10	40	" "	Nil	4.9
5	10	45	" "	2.5	7.4
6	10	50	" "	5.0	9.7
7	5	40	5 ccs. of 5N.NaOH	10	7.6
8	5	100	25 ccs. 5N.NaOH	40	30.0
9	5	30	Just alkaline	5.0	8.8
10	5	30	Just alkaline plus 50 ccs. water.	5.0	8.9
11	5	30	Neutralised plus 5 ccs. NaOH	5.0	5.2
12	5	30	As in 11 plus 50 ccs. water.	5.0	5.3

From the experimental work and subsequent practical application, it was deemed that the object of providing a reliable useful analytical scheme was entirely fulfilled.

For direct comparison with the querist's work the data in the following table have been obtained, and on these the following comments are made :

The cadmium solution was prepared from pure cadmium dissolved in nitric acid, taken to fumes with sulphuric acid, excess acid evaporated, and the solution diluted, so that it was only just acid.

The test series Nos. 1 to 6 show that in faintly-acid solution, the test fails ; test No. 4 should have required exactly 5 c.c. of Ag No. 3, and required 4.9, while Nos. 5 and 6 were in excess by approximately the same amount within the limits of experimental error. This series is in agreement with the querist's first table of results and it is presumed that he also was working with faintly acid solutions.

The remaining tests deal with alkaline solutions. In Nos. 7 and 8, heavy additions of caustic were made, and the actual titrations were difficult to read and therefore uncertain, which may account for their being low. The causticity corresponds to about 3½ and 6½ oz. NaOH per gall. ; taking 4 oz./gall. as a probable maximum in a plating solution, and the original test method stipulated dilution of 10 cc. to 40 cc., so that in the actual titration of a plating solution the causticity would be of the order of 1 oz./gal. maximum.

Tests 9 and 10, in which the faintly-acid cadmium solution was taken just beyond neutral, show firstly that they behave similarly to the faintly acid solutions, and that the alkalinity is insufficient, and secondly, that the result is independent of dilution.

In tests 11 and 12, the test solutions contain approximately ½ and ¾ oz. NaOH/gal., respectively. Within the limits of experimental error, the results are accurate. As this represents the most probable range of concentration in commerce, it is deemed that the method is established as satisfactory.

The above experimental work was specially carried out by an unbiased observer who, incidentally, was not concerned in the original research. Commenting on the querist's results briefly in the light of this new data :—

- (1.) His first table of results has been remarked upon above, and corroborated. The test does not hold in faintly acid, neutral or faintly alkaline solutions.
- (2.) The suggestion that the solubility of cadmium cyanide in water, and the suppression of this solubility by the right amount of causticity, as the explanation of (1) is probably correct.

(3.) The results in the second table are virtually confirmed, but their interpretation by the querist is masked by an error—viz., 10 cc. N/10 CdSO₄, 10 cc. N/10 KCN, 50 cc. N/3 NaOH corresponds to approximately 1½ ozs. NaOH/gal., not 10 oz., and this titration and the preceding one are regarded as of sufficient accuracy for practical purposes.

(4.) The results in the final table with 1 to 4 ozs. NaOH/gal. are deemed to be of sufficient accuracy.

It is commented that with extended practice the user will develop greater skill in judging the end-point and attain better accuracy. Finally, the writer thanks the querist for putting forward his difficulties and giving him the opportunity of commenting upon them.

Yours, etc.,

E. E. HALLS.

Sir,—In thanking Mr. Halls for his courtesy in taking this matter up, we would like to add the following notes in answer to his remarks :—

1. Regarding the first table of results, the method of making cadmium double cyanide solution was to use A. R. Cadmium sulphate and adding potassium cyanide. This gave a faintly alkaline solution.

The author's solution is presumably acid due to the H₂SO₄ in the CdSO₄.

2. The solution we actually used in table II. did contain 1½ oz. NaOH, as you state, but this represents 10 ozs. per gall. of NaOH in an original plating solution, where a 10 cc. sample is taken and diluted (in our case) to 70 ccs.

Our results tend to show that a plating solution would have to contain 10 oz. per gall. of NaOH, in order to give quantitative results, whereas, in fact the normal plating solution only contains a maximum of 4 ozs. per gall., and usually it is only 2 oz. per gall.

3. The results obtained with additions of 1 to 4 ozs. NaOH are not considered to be accurate enough where a close control of colour is desired, and where free cyanide is highly important.

We should mention that we have been carrying out this test for over six years with periodic checking by determination of total cyanide.

Yours etc.,

J. DAWSON.

Dear Sir,—I certainly feel that Mr. Dawson's efforts at process control of plating solutions are highly commendable. Cadmium solutions are apt to fluctuate a lot, and colour variations to a detrimental extent that I have investigated have largely been due to one or more of the following reasons :—

1. Build-up of cadmium in the solution with ultimate sludging.
2. Excessive iron in the solution, due to badly impure cadmium oxide, or to iron gradually accumulating from the vat itself or from iron anodes.

3. The incorrect practice of using lead-lined tanks.

I have found a fair latitude in the free cyanide content detrimental, except in so far as (1) above is concerned, viz., as it approaches nil there is a strong tendency for sludging to occur.

New Barnet,
Herts.

Yours etc.,

E. E. HALLS.

[Probably many readers are experiencing similar difficulties in which case this correspondence will be helpful : for this reason it is published.—EDITOR.]

World output of cadmium increased from 1,000 tons in 1932 to 2,300 tons in 1934, the chief producing countries being the United States, Tasmania, France, Poland, Norway and Canada. Production is limited entirely to by-product recovery from electrolytic zinc and lithopone. There is every likelihood that world output will continue to increase

Metallurgical Literature and the Technical Library

By A. D. ROBERTS, F.L.A., Librarian, Technical Library, Birmingham.

The Technical libraries are not used as much as they could be with profit and although the author of this article invites readers to the Birmingham technical library similar facilities are available in many of the London and Provincial libraries for scientific workers who seek information. Help is given in every possible way.

METALLURGISTS, in common with many other scientific workers and technicians, still display a considerable ignorance of the literature of their subject, and often set about tracing information on it in a very cumbersome fashion. The purpose of this article is to outline briefly the elementary methods of keeping in touch with current advances and of undertaking research, and to name some of the chief publications likely to be needed. The publications in question are to be found in the majority of the technical libraries in our largest cities and towns: certainly they are nearly all available in my own library, in Birmingham. Institutions of this kind can serve the practical man wishing to solve a difficulty in plating-room procedure and the research worker interested in the microstructure of a particular alloy equally well. Those who are fortunate enough to be within easy reach of their society's library, or who have a special library at their works are, of course, specially catered for. Yet, even they may frequently use a general technical library with advantage. A person interested in investigations regarding super-conductivity, for instance, will find his material appearing in such diverse periodicals as the *Review of Modern Physics*, *The Review of Scientific Instruments*, and the *Canadian Journal of Research*.

To keep in touch with current advances one must, of course, read the leading periodicals as they appear, and take care to examine the relevant sections of the abstracts and bibliographies published in so many of them. Members of such societies as the Institute of Metals, The Iron and Steel Institute, The British Non-Ferrous Metals Research Association, and the Cast Iron Research Association will begin with their own journal. The abstracts published in papers like the *Light Metals Review*, and the *Nickel Bulletin* should not be overlooked, nor should those which appear in the American journal *Metals and Alloys*. The authoritative publications of bodies like the American Electro-Chemical Society and the American Institute of Mining and Metallurgical Engineers also deserve examination. Some of the abstracts and references may require following up, and the fact that they may appear in abstruse foreign periodicals should not deter the reader from inquiring for the original. If the journal needed is not immediately available, it may usually be borrowed from another library. In addition, the monthly issues of the *Industrial Arts Index* and the annual volumes of the *Engineering Index* should be checked under likely subject headings. The former has the advantage of being more current and indexing more minute material, while the latter gives abstracts, instead of a plain entry, and has an author index. Going further afield, there are numerous special bibliographical tools which can, on occasion, be used with advantage. Examples are *British Chemical Abstracts*, *Building Science Abstracts*, and the *Index to the Literature of Food Investigation*. Some technical libraries have their own classified files of clippings available.

Tracing Information

In endeavouring to trace information on any specific subject the procedure adopted should vary with the age of the subject, but as a general rule it is best to exhaust the information in book form first, and this is facilitated in most technical libraries by the classified arrangement of the books on the open shelves. It is as well to remember

that because a book dealing specifically with your subject does not give you what you want, it does not follow that the information will not be contained in a more general work. It is often possible to utilise books written in a language you do not understand, especially if you merely require a figure, say, a specific heat or melting point. Excellent special language dictionaries like Freeman's *Fachwörterbuch der Metallurgie* are available, and the staff will be willing to help. If a book dealing with your subject is too brief or otherwise unsatisfactory, it is as well to see if it has a bibliography, or if any of the references the author makes are worth following up. Then, if the books have definitely proved useless, turn to the periodical literature, utilising the indexes at the back of bound volumes of abstracts. Especially useful for quick work are the cumulative indexes covering several years, though, since they are infrequently published, they may be no longer current. There are cumulative indexes to the publications of the American Society for Testing Materials, *Metals and Alloys*, and *Stahl und Eisen*, as well as to the publications of the Institute of Metals and the Iron and Steel Institute. Then the annual and monthly issues of the *Industrial Arts Index* and the volumes of the *Engineering Index* will need to be consulted. More specialised still are the weekly lists of additions to the Science Library and the periodical *Repertorium Technicum*. If the search still proves fruitless, scan as many back numbers of likely periodicals as possible, for the point in question may have been dealt with in a paragraph which has not been deemed of sufficient importance for indexing. Finally, an appeal may be made to one's society (if this has not already been done), or to an official body like the Science Library or the appropriate section of the Department of Scientific and Industrial Research.

Basic Literature

It is impossible to summarise adequately periodical literature, but an attempt may be made to show how books are selected in a general technical library, and some of the broad groups into which they fall. In Birmingham, for instance, it is the practice of the staff to make a thorough survey of all the periodicals as they arrive, and to purchase the majority of books which are favourably reviewed. An institution which can afford Beilstein's *Handbuch der organischen Chemie* can purchase most of the books likely to be asked for. Other sources examined are the lists of additions to the libraries of the various societies as published in their journals, publishers' catalogues and the English and American book trade bibliographies. Lists of additions to the Science Library and various public libraries in England and abroad, the monthly *Technical Book Review Index* of the Special Libraries Association (of America), and the quarterly list published by the Association of Special Libraries and Information Bureaux are also checked. Much of the most valuable and practical literature is fugitive; that is, it does not get entered in the usual lists. Hence the necessity for using so many sources. The really keen metallurgist will learn to use some of these tools himself.

The basic stock may be said to consist of the pure reference works like the *Metal Industry Handbook* and the *National Metals Handbook*, lists of alloys, encyclopaedias and works like the *International Critical Tables*, and Landolt and Bornstein's *Physicalisch-chemische Tabellen*.

Standards and specifications are increasing in number and are being more frequently demanded by buyers. In addition to the publications of the British Standards Institution and the Air Ministry, the standards of such bodies as the American Society for Testing Materials, and the Society of Automotive Engineers are in constant use. Another large group of works frequently needed consists of publications of official bodies and development associations. The Department of Scientific and Industrial Research and the Bureau of Standards in America are amongst the most important of the former, while among the latter the Copper Development Association and the International Tin Research Association are prominent. Neither does the technical library hesitate to keep and catalogue the best of the trade literature issued by individual firms. Standard works like Sauveur's *Metallurgy and Heat-Treatment of Iron and Steel*, and Crook's *Metallurgical Spectrum Analysis*, are always to be found available in the latest editions. In conclusion, the author invites interested readers to visit the Technical Library in Birmingham, to examine any of the works mentioned with which they may not be familiar. Every effort is made to answer inquiries of all types, whether received by letter, telephone, or personal application.

Geological Investigations in Canadian North

The Department of Mines at Ottawa is sending two geological parties into the little-known Canadian North, with instructions to carry examinations as far north as the Arctic Circle. Each party will be composed largely of students in geology and mining from the University of Alberta and the University of Saskatchewan, with enough trained geologists to permit the operation of sub-parties.

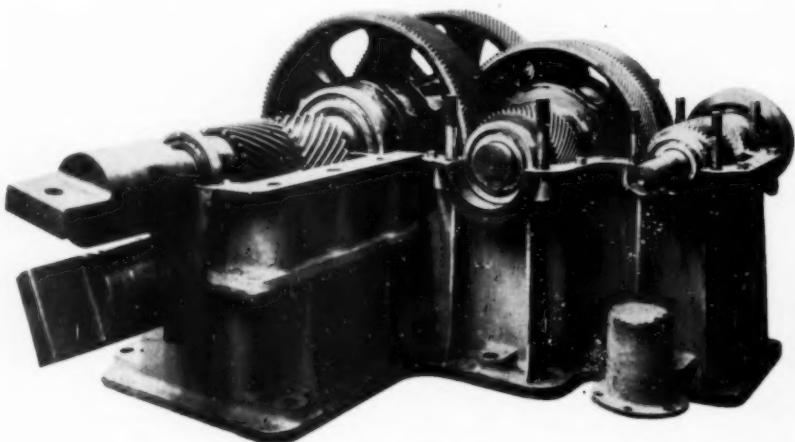
Last year the Department mapped a 10,000 square-mile area in the vicinity of the Yellowknife river basin, northeast of Great Slave Lake, approximately one-third of which has been defined as excellent prospecting ground for precious metal deposits. One of the parties will, this year, undertake the examination of a 10,000 square-mile area to the southeast of Great Slave lake. Nothing is known of the geology of the area, with the exception of a narrow strip along the Talston river, which was examined in 1914 by Dr. Camstell, now Deputy Minister of Mines. His initial exploration indicated the presence of belts of greenstone, which suggest the occurrence of mineral deposits. Work in the area this summer is designed to trace the extensions of these favourable belts; to locate and map other similar belts in the region; and to examine known mineral occurrences, including the recent gold strike east of Talston river.

The other geological party will make a detailed examination of the mining properties located between Lake Athabasca and Great Bear Lake. These include the gold deposits on the north shore of Lake Athabasca and on Outpost Islands, Yellowknife Bay; the pitchblende deposits at Hottah and Hardisty lakes; and the deposits of radium and silver ores at Echo Bay, Great Bear Lake.

Commercial aircraft will be used extensively in the work of the two parties as it has been in all recent mining operations in the north. Aircraft will be used for initial reconnaissance work; for the transportation of men and equipment to favourable locations; and as a means of maintaining contact among the several sub-parties.

Combined Double Reduction Gear and Pinion Housing for Bliss Cluster Mill

WHilst it would be wrong to include the motor industry as a whole in the heavier engineering trades, one of its ancillary branches, devoted to the rolling of steel sheets for motor bodies and paneling work, undoubtedly comes under this category, and it is noteworthy that a new innovation in rolling-mill drives is applied to one of these mills in the south Midlands.



Rolling mill drive for rolling steel sheets for motor bodies.

It is a self-contained unit comprising a double reduction gear and rolling-mill pinion housing, and embodies comparatively small-pitch double helical gears and rolling-mill pinions generated by the hobbing process, which is usually associated with turbine gearing. Generation of the teeth in this manner and employment of heat-treated high-tensile steels ensures the quietness and efficiency required in the modern rolling-mill plant. The two sets supplied, after working continuously for five years—during which time they have been subjected to exceptionally severe duty—are still functioning satisfactorily, and show no appreciable sign of wear. After such a gratifying report, we think the time is opportune for giving a brief detailed description of their design and construction.

The accompanying illustration shows one of these gears which has been designed and manufactured by David Brown and Sons (Hudd.), Ltd., for rolling steel sheets up to 50 in. in width, which are brought down from 16-gauge to 20-gauge in four passes, the rolling speed being about 100 ft. per min. Heavy shocks are transmitted directly to the gears each time a sheet enters and leaves the rolls. Loads of 250 h.p. + 25% for two hours and 100% momentary overload at 1,000 to 90·9 r.p.m., and 340 h.p. with similar overloads at 330/30·3 r.p.m., are transmitted. To ensure a generous margin of strength, the wheels are made from 0·4 carbon steel castings, and the reduction-gear pinions from 0·5 to 0·55% carbon forged steel. The primary reduction gears work at 25-in. centres, and the secondary gears at 33-in. centres. The rolling-mill pinions, also of 0·5 to 0·55% carbon forged steel, each have 25 teeth of 1·76 in. circular pitch, with a 24-in. working face, and operate at 14-in. centres. One of these pinions is integral with the slow speed shaft of the double-reduction gear.

The whole unit is arranged in a substantial cast-iron case of special design, and well ribbed at points of stress. Lubrication is by oil bath contained in the bottom half of the case. Roller bearings are provided throughout the whole set. The bearing between the double reduction gear and the pinion housing is 15-in. diameter, in order to pass over the roll pinion, thus obviating the removal of the second reduction wheels in the case of bearing replacement.

Recent Developments in Materials, Tools and Equipment

Special Annealing Furnace for Crankshafts

A SOMEWHAT unusual type of annealing furnace has recently been put into operation at the Dagenham Works of Messrs. Ford Motor Co., Ltd., for the treatment of cast crankshafts produced by them. The furnace is unusual in so far as it is of the double-deck type, and is in reality two furnaces, one placed above the other. This design economises in floor space, and also makes it possible for one operator to run the furnace as the crankshafts after treatment are returned to the operator at the charging end.

The crankshafts are placed on heat-resisting alloy shoes, two 8 h.p. or one V. 8 crankshaft being placed on one set of shoes. The shoes with their load are then pushed into the lower chamber by means of an electrically-driven pusher. The lower chamber is divided into two zones, the first being the pre-heating zone where the crankshafts are heated slowly to the required temperature. The second chamber is maintained at a constant temperature, and in this chamber the crankshafts are soaked for a predetermined period.

The crankshafts and shoes are discharged from the lower chamber by means of a special form of extractor gear, which at the correct moment enters the furnace and extracts one set of shoes with crankshafts from each line passing through the furnace. The extractor gear carriage with the shoes and crankshafts is then elevated to a position opposite the charging end of the upper chamber, and in line with a second pusher. During the period between leaving the bottom chamber and being pushed into the upper one the crankshafts are fan-cooled through a specified range.

The upper chamber is divided into three zones, pre-heating, soaking and cooling. In the first the load is heated slowly to the required temperature and then soaked in the second chamber for a given time, after which the crankshafts are cooled in the third zone at a controlled rate.

The operation of pushing the shoes into the upper chamber also discharges a set of shoes from the cooling chamber which travel down an inclined roller table on to a gravity lowering gear. This gear delivers the shoes and crankshafts to the charging point of the lower chamber where the crankshafts are removed, and the shoes used for further charges.

The whole cycle of operations from beginning to end is electrically controlled, and each movement in the cycle is interlocked with the next, to prevent overlapping and to ensure correct sequence. Push-button control is provided so that the cycle can be stopped and started when and where necessary.

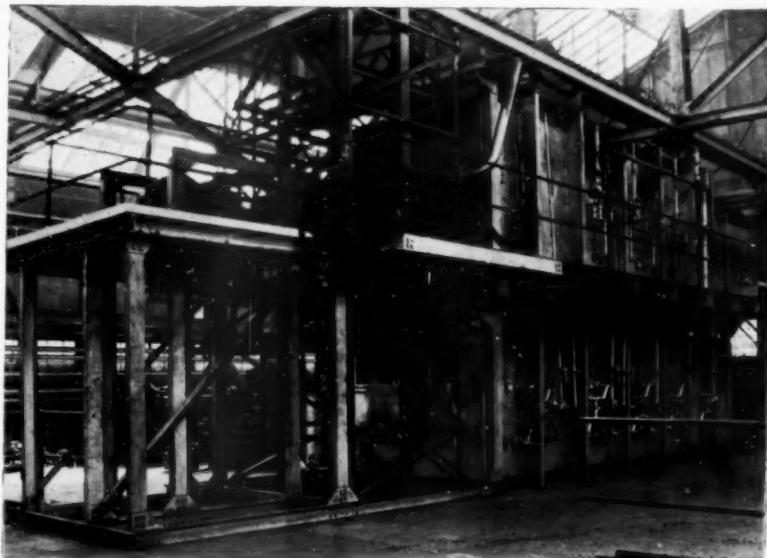
The furnace is fired by means of coke-oven gas and special precautions are taken to prevent the gases from the burners impinging on the stock being heated. An even temperature is essential throughout each zone, and by careful design this has been obtained.

The atmosphere in the furnace is equally important, and this is controlled by the special automatic proportioning burner equipment to produce a non-oxidising condition. The crankshafts are, therefore, heated with a minimum of scale.

A special system of flues is incorporated in the design of

the furnace, by means of which the waste heat from the bottom chamber can be utilised in the upper chamber or passed direct to the recuperator arranged on the top of the upper chamber.

Owing to the fact that the coke-oven gas used for heating



An annealing furnace specially designed for motor car crankshafts.

the furnace contains a high percentage of sulphur, the heat-resisting alloy is of a special analysis, which is resistant to the action of sulphur.

The heating and soaking zones of each chamber are automatically controlled with regard to temperature by Leeds and Northrup instruments of the potentiometer type, supplied by Messrs. Integra and Co., and these instruments in conjunction with the Surface Combustion automatic proportioning single-valve control type of burner equipment ensure ideal heating conditions.

The furnace is designed for an output of 650 cranks per day of 16 hours, representing a total of about 13 tons of stock, and this is the nett amount of material to be heated in the furnace. The gross output is represented by the above weight, plus the weight of the shoes on which the cranks are placed.

With the exception of the transfer gear, which was supplied by Messrs. Herbert Morris, Ltd., of Loughborough, the installation was designed and constructed by Messrs. British Furnaces, Ltd., of Chesterfield, in collaboration with the Engineering Staff of the Ford Motor Co., Ltd.

Iron and Steel Institute

New President :

The Council of the Iron and Steel Institute announces that Mr. Alfred Hutchinson, M.A., B.Sc., Vice-President, (Director of the Skinningrove Iron Co., Ltd.), has been nominated President of the Iron and Steel Institute, to take office in May, 1937, on the retirement of the present President, Sir Harold Carpenter, F.R.S., and that the Right Hon. the Earl of Dudley, M.C., Member of Council, (Chairman of the Earl of Dudley's Round Oak Works, Ltd.), has been nominated President, to take office in May, 1938.

New Aluminium Laboratory at Banbury

A further stage in the expansion of the Northern Aluminium Company's activities at Banbury is about to be completed by the opening of their new laboratory building, shown in the accompanying illustration. A large proportion of the building, which has a total floor area of 13,750 sq. ft., is devoted to laboratories, the remainder being used for administration offices.



Reproduced from the Architect's drawing of the new Laboratory Building.

Aluminium and aluminium alloys have been extensively used in the construction of this building. The main entrance doors have been specially designed. They are cast in aluminium alloy and given an anodic treatment. The window frames and sashes are in aluminium alloy, anodically treated, as are the banisters, hardware and electric light fittings. Aluminium spandrels have also been incorporated with good effect, and effectually demonstrate how aluminium can be used with advantage, from both an artistic and economic standpoint.

The equipment in the existing laboratories will be transferred to the new building, and in addition there will be installed Wöhler type fatigue-testing machines, an additional Amsler tensile testing machine and an Izod impact machine. Further equipment of special interest is an X-ray unit and a projection microscope.

A special research department will be equipped with remelting, annealing and heat-treatment furnaces, all with automatic temperature control. This new equipment will enable the research work now in progress to be much extended.

Development of Wolfram Deposits in Southern Rhodesia

A new mineral discovery leading to the development of one of the most promising wolfram deposits has enhanced the mining importance of the Wankie area in Southern Rhodesia. The mine, which is known as the Tshoutanda, but registered as the Sequel, was opened up by Messrs. Aldworth and Sauerman about two years ago, who produced wolframite to the value of £10,000. This was almost entirely from open stopping of the outerops.

The development of the mine involved a considerable expense to overcome the natural obstacles. This outlay was faced by Rhodesia Chrome Mines, Ltd., who took an option over the property, and after full examination exercised the option and floated a new company, St. Swithin's Ores and Metals, Ltd., to work the property. The mine is being developed largely by adits, which are practicable because the deposit is in a hill. Development is now sufficiently advanced, and there is enough ore in sight to warrant the installation of a plant. The machinery, which will shortly be available, will crush 120 tons a day at the start.

The treatment is purely mechanical and consists of dealing with the concentrates, which are not unlike those of tin. There has been a small mill on the property, and this has been used as a sampling mill. By the use of this mill it has been possible to make the most satisfactory of all

tests, actual milling, and the results encouraged the establishment of the larger plant.

There is a good-sized ore body and some of the samples are unusually rich and true exhibition specimens. The deposit at the Sequel is not the only one discovered in the neighbourhood, and the company has pegged claims along some 45 miles of strike crossing the railway some ten or a dozen miles south of Wankie. The general formation of the country rock is gneiss and granite with pegmatite intrusions. The district is near the southern margin of the Wankie coalfields, and its mineral wealth is a comparatively new discovery.

Fortunately there are no metallurgical problems to be overcome in dealing with the ore. Wolfram, which is tungstate of iron and manganese, occurs as a black ore of jet-like brilliance. Over 1% is needed for profitable working, and the milling tests at the Sequel give a far better showing than this.

A New Type of Metal Plant in the Donetz Basin

A new type of metallurgical plant is being built in the Krivoi Rog ore basin for the production of spongy iron by direct reduction of the ore without the use of blast furnaces. The opening of this plant will mark a new stage in the development of the Soviet iron and steel industry. The inventor of the new method, the Soviet engineer L. Trautman, discussing this development said that experiments for the direct reduction of ore to iron without the use of blast furnaces have been conducted by metallurgists throughout the world for many decades. All of these experiments, however, have failed to produce practical results. The methods used abroad for reducing iron by electricity are so expensive that the industrial application of them has proved to be impracticable.

The method suggested to the Ivanovo-Experimental Plant represents a totally new approach to the solution of the problem. The Plant designed a special furnace for the direct reduction of iron and obtained very good results. A large plant assigned by the Commissariat of Heavy Industry in Krivoi Rog will verify on an industrial scale the results obtained in the experimental stage. The method completely eliminates the use of electric power in the reduction of the ore. Any fuel, such as peat, shale, coal, coke and anthracite waste, shavings and so on, can be used in the application of the method.

Pulverised ore which cannot be used in the blast furnaces, is the raw material employed, the expenditure of fuel per ton of spongy iron does not exceed that which is normal in smelting similar iron by the blast-furnace method, and there are good prospects for reducing the cost of the metal.

It is claimed that this new method of producing spongy iron opens up vast opportunities for the manufacture of high-grade steels and ferro-alloys in the U.S.S.R. It will make possible the development of the iron and steel industry in those numerous parts of the country which have abundant ore, but no coking coals, or have crushed ore deposits which require considerable outlays for agglomeration. The spongy iron produced is of a chemical composition, which makes it into splendid material for the production of the finest steels and iron of high purity. The sulphur and phosphorus content of the spongy iron does not exceed 0.04%. The Urals has huge deposits of titanium-magnetite ores, which cannot be smelted in blast furnaces, owing to their high titanium content. This ore can be reduced by means of the new method, and about 95% of the titanium and vanadium contained in the ore can be extracted and made into ferro-titanium and ferro-vanadium.

The Krivoi Rog Plant will be put into operation at the end of this year. The chemical processes and the apparatus are so simple that three workers will be able to operate a number of units each with a production capacity of 50 to 100 tons of iron per day.

Business Notes and News

New Coke Ovens at Middlesbrough

It is expected that half of the battery of coke ovens under construction at the Cleveland steelworks of Messrs. Dorman, Long, and Co., Ltd., will be put into operation this month. The plant, the cost of which will be about £600,000, will be the largest in this country and the second largest in Europe. The battery consists of 136 ovens, and when in full action will achieve the object of centralised production of the coke-making plant, Messrs. Dorman Long, have in view.

Fusion of Engineering Works

Messrs. Sulzer Bros. (London), Ltd., announce that they have acquired as a going concern the business of Messrs. Hathorn, Davey and Co., Ltd., Sun Foundry, Hunslet, Leeds, to enable them to manufacture in this country with their own organisation and equipment. For this purpose it is stated that a considerable sum of money is being expended on the modernisation of the works, new machinery and equipment. It is noteworthy that this arrangement will not interfere with the manufacture by Messrs. Hathorn, Davey and Co. Ltd., of their own products and that they will continue to maintain their separate connections.

Recently Formed Electric Furnace Firm

A new name has been added to the electric furnace industry by the formation of Metalectric Furnaces, Ltd., Smethwick, Birmingham. We understand this Company has acquired world-wide rights and licenses for both the manufacture and sale of an important series of basic furnace patents and processes which have attained universal recognition throughout the metallurgical industries. Its Smethwick Works, which are modern and extensively equipped, incorporating iron and steel foundries, machine, erecting, steel work, welding and sheet metal shops, physical and chemical research laboratories, provide adequate facilities for the specialised and complete manufacture of all types of electric furnaces and equipment together with "Metalectric" refractory heat-resisting metals.

The furnaces cover a complete range of types and processes for the ferrous and non-ferrous industries, from small portable units, low-temperature re-circulating systems, to the largest mechanised full-automatic continuous units with auxiliary equipment for bright annealing, atmosphere control and similar processes. A competent staff is available possessing highly specialised and wide experience in the design and application of Electric Furnaces to every phase of the Metallurgical industries.

The United Steel Company's London Office

The London Office of The United Steel Companies, Ltd., is now at 8 and 10, Grosvenor Gardens, Victoria, London, S.W. 1. Telephone: Sloane 4833.

This office represents the following branches and associate companies:—Steel, Peech and Tozer, Sheffield; Samuel Fox and Co., Ltd., Sheffield; United Strip and Bar Mills, Sheffield; Appleby-Frodingham Steel Co., Ltd., Scunthorpe; Daniel Doncaster and Sons, Ltd., Sheffield; Workington Iron and Steel Co., Workington; The Rothervale Collieries, Treeton; United Coke and Chemicals Co., Ltd., Workington; and Thos. Butlin and Co., Branch, Wellingborough.

Specification for Enamelled Copper Wire

Since the British standard specification for enamelled copper wire was revised in 1932, some further research has been undertaken by the Electrical Research Association to determine the effect of voltage on the number of pinholes detected in enamelled wire. As the result of these investigations, certain modifications have now been made to the details of carrying out the pinhole test, and these modifications are incorporated in a revised edition of B.S.S. 156, which has just been published. There are no changes in the specification other than as regards the pinhole test, but in view of the importance of this particular test the immediate issue of a revision has been considered desirable.

Copies of this revised specification (B.S.S. No. 156, 1936) may be obtained from the Publications Department, British Standards Institution, 28, Victoria-street, London, S.W. 1, price, 2s. 2d., post free.

Activity in Iron and Steel Trade

Pig-iron production continues to expand in all parts of the country where the industry is established. Inquiries for supplies have fallen slightly, but there is no lack of demand. Many consumers are refraining from placing new contracts for the time being, because of the difficulty in obtaining deliveries, but others remain keen to obtain additional supplies. Some producers are experiencing difficulties in completely fulfilling their obligations. Output is just about equal to current needs, but does not give sufficient margin to overtake arrears of delivery.

It is noteworthy that East Coast Haematite Manufacturers have advanced their prices by 5s. per ton. A rebate of 5s. will, however, be given to consumers confining their purchases to members of the Haematite Producers' Association. The scheme is designed to protect makers against possible competition from outside producers, and any Continental competition which may arise following de-valuation of currency in certain countries.

There is considerable demand also for semi-finished and structural steels, and great pressure for deliveries is being experienced, which is likely to be experienced throughout the autumn. Steelmakers are feeling the benefit of the increased demands of the shipbuilding industry and plants are working near to capacity in order to ensure deliveries.

Steel Output in June

At the end of June, according to the monthly returns of the British Iron and Steel Federation, 112 furnaces were in blast, three having been blown in and three put out of operation during the month. The production of pig iron in June amounted to 644,100 tons, compared with 661,000 tons in May and 529,300 tons in June, 1935. The month's production included 154,200 tons of hematite, 354,500 tons of basic, 109,800 tons of foundry, and 10,500 tons of forge pig iron. The production of steel ingots and castings in June was 965,900 tons, compared with 963,000 tons in May and 770,000 tons in June, 1935.

Another Steel Company Installs Pension Scheme

Several iron and steel works have recently installed pension schemes for the benefit of their employees. Another to be added to the list is the Neepsend Steel and Tool Corporation, Ltd., who have put into operation a contributory scheme. The Company seems to have adopted a reasonable attitude in drawing up the scheme, as it is understood that the contributions from the employees will provide less than half the cost of the pensions, the balance being made up by the Company, who also assume the entire cost of the life insurance and disability benefits which are provided.

The scheme provides for the pensioning of male workers at 65 and of female workers at 60; the pensions being payable at those ages whether the workers retire or continue in employment, provision is also made for earlier retirement within five years of those ages by mutual agreement, the pension being adjusted accordingly. All employees are eligible to join the plan who are 21 years old and have been with the Company for three years. Others will join as they become eligible.

Members of the plan are divided into various grades for the purpose of fixing contributions and benefits according to their earnings.

Valuable Mineral Discovery in Southern Rhodesia

News has come of another valuable mineral discovery in Southern Rhodesia which may prove of great importance to that Colony. A lode of tin-stone (cassiterite) and of tungsten has been prospected and pegged for a distance of over 30 miles. Tungsten had already been found in the same area before, but the discovery of tin is entirely new. From examination of hand samples brought into Bulawayo, it is believed that a valuable new industry will soon be established. Much activity is being displayed in development work, and one of the parties concerned has already started production.

The prospectors have shown considerable enterprise and fortitude, for the area is very broken, hilly and, in many places, entirely waterless on the surface. So thoroughly have they done their work that there is apparently no more of the strike to be pegged. No difficulty in obtaining water, by means of bore holes, wells and pumps, is anticipated.

Some Recent Contracts

Darlington Firm to Build Howrah Bridge

The contract for the great new bridge, which is designed to span the river Hooghly at Howrah, Calcutta, has been obtained by the Cleveland Bridge and Engineering Co., Ltd., Darlington, after much controversy, which has extended over several months. The Cleveland Company, it is understood, have offered to place a substantial order for Indian steel and cement, and proposed that the bridge should be partly built in England and completed in works to be laid down at Calcutta.

The bridge, which will take four years to build, will carry a road, tramlines and footpaths. Howrah is a busy industrial suburb on the right bank of the Hooghly, opposite Calcutta. The value of the contract is about £1,750,000. With a main span of 1,500 ft., the new bridge will be one of the biggest in the world. The outstanding feature of the Howrah Bridge, which will replace the present 60-year-old floating structure, will be two colossal main towers, one resting on each bank of the river. They will rise 300 ft. high. About 17,000 tons of high tensile steel and 9,000 tons of mild steel will be used.

Dredging Plant Contracts

A series of dredging plant contracts has been placed with Messrs. William Simons and Co., Renfrew, by British and overseas port authorities. The contracts are from India, Iraq, and the Mersey and involve seven vessels. These include a powerful suction hopper dredger of 3,000 tons for Iraq, to be employed in extensive dredging operations; a large non-propelling bucket ladder dredger, with a dredging capacity of 1,400 cu. yards per hour, for Cochin, India; three 700-ton hopper barges, fitted with special machinery, arranged for discharging the dredged load overside by a powerful centrifugal pump, also for Cochin; and two 1,200-ton grab hopper dredgers for the Mersey Docks and Harbour Board, to be employed in their extensive dock improvements.

In addition to the hulls of these vessels, Messrs. Simons will supply all the machinery.

Re-organisation of the Maintenance of the L.N.E.R. Line between Galashiels and Carlisle

The L.N.E.R. has just ordered from Messrs. D. Wickham and Co., of Ware, a 36-seater petrol trolley for the purpose of conveying permanent way gangs to and from their work. This trolley will form part of the transport service required in connection with the re-organisation of the maintenance of the L.N.E.R. main and branch lines between Galashiels and Carlisle which has been inaugurated by Mr. W. A. Fraser, L.N.E.R. Engineer for Scotland. The new trolley completes the equipment of which there is already in service a similar petrol vehicle and 11 smaller petrol trolleys capable of seating 10 men each. Six of these smaller trolleys are provided with trailers for the purpose of carrying material.

Each of the larger trolleys will be used for mobile relaying gangs, whose work extends between Galashiels and Carlisle, each trolley covering a section of about 32 miles. The smaller trolleys are for the use of the length gangs, whose work is generally limited to short lengths of about six miles. The employment of these modern methods has considerably increased the efficiency of the work and has resulted in considerable savings in locomotive cost.

L.M.S. New Wagons

Contracts have been placed by the London Midland and Scottish Railway with five British firms for a total of 1,000 20-ton wagons for the conveyance of locomotive coal. The orders include 250 from the Metropolitan Cammell Carriage and Wagon Co., Saltley; 150 from the Birmingham Railway Carriage and Wagon Co., Smethwick; 100 from Messrs. G. R. Turner and Co., Ltd., Langley Mill, Notts.

These 500 wagons will have the body plates, side and angle rails made in copper-bearing steel, while the following 500 will have these parts in wrought-iron:—300 from the Gloucester Railway Carriage and Wagon Co.; 200 from the Fairfield Shipbuilding and Engineering Co., Chepstow.

The Union Government Railways, it is understood, have placed an order for trucks worth £167,800 with Metropolitan Cammell Carriage and Waggon Company, Birmingham.

Catalogues and Other Publications

Barrow Haematite Steel Co., Ltd., Barrow-in-Furness, have just issued a booklet dealing with refined pig iron for malleable iron castings. The use of pig irons which are regular in composition and true to analysis is of great importance in the production of malleable-iron castings, and has inspired this Company to incessant research work, not only with the object of attaining the maximum degree of uniformity, but with a view to the recommendation of the most suitable grades of pig irons for individual requirements. The information given in this booklet on the manufacture of both whiteheart and blackheart malleable-iron castings will be useful and serve to encourage the production of malleable castings of the high standard obtainable to-day.

Thos. Firth and John Brown, Ltd., Sheffield, have issued an interesting booklet giving details of their principal carbon and alloy steels. Full data concerning each is given, and include typical analysis, heat-treatment, mechanical and other salient properties, standard specifications met, instructions for manipulation, and applications and uses. For convenience the steels are subdivided into different classes: carbon steels medium tensile and alloy steels, high tensile alloy steels, casehardening steels, nitriding steels, spring steels, ball-race steel, non-expansive steel, high expansion magnetic steel and magnet steel. The data given facilitates the selection of a suitable steel for a given purpose.

Hadfields, Ltd., Sheffield, have sent us a booklet dealing with "Era H.R." heat-resisting steels. These steels have a high rigidity and are free from appreciable scaling at temperatures up to 1,100° C. They are especially suitable for all engineering uses involving high temperatures and oxidising conditions. The booklet describes these steels in some detail, giving data and information which should be in the hands of users of such steels.

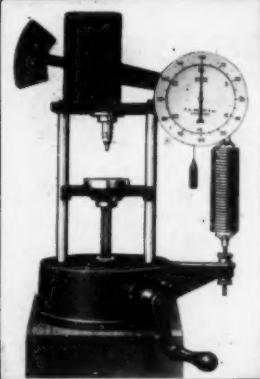
Questal Bentonite: its application in the foundry, is discussed in a booklet issued by Quest Products, Ltd., Wharton, Winsford, Cheshire; it is claimed that this material has been the means of obtaining better castings, and this booklet points out how it can best be utilised for this purpose. It contains much useful information.

A new range of models of the well-known Hilger Quartz Spectrographs is described in a booklet recently received. These include the three instruments which are known all over the world as the small, medium and large models. All of them have been redesigned and take the Hilger Accessory Bar for the correct alignment of accessories. The large instrument is now offered in a fully automatic model, which is of great advantage in the industrial control of metals and alloys. A new size spectrograph has been introduced, intermediate in size between the small and medium, and therefore known as the intermediate. An exceptionally complete range of accessories is described for both qualitative and quantitative analysis, including outfits for the Stepped Sector and the Lundegardh Flame methods.

This booklet, which gives sound advice on the choice of apparatus for specific applications, is entitled "Spectrographic Outfits for Metallurgical and General Chemical Analyses. Copies may be obtained from Adam Hilger, Ltd., 98, Kings Road, London, N.W. 1, post free.

"THE PROPRIETORS of the BRITISH PATENTS Nos. 409910, 409911 and 423697 for 'Process for refining crude copper,' 'Process for the deoxidation and purification of copper' and 'Process for the deoxidation of copper,' are prepared to enter into negotiations for the SALE of the patents or for the grant of LICENCES thereunder.

Any enquiries to be addressed to C. & R., 24, Southampton Buildings, London, W.C.2."



**125 kilos
BRINELL & DIAMOND
Hardness Testing Machine**

Will apply loads from 5 to 125 kilos, progressively and without shock. Provided with very full equipment including diamond and ball indenters and quick registering microscope. For testing all classes of materials including thin strip metal and hardened steel.

Send for full particulars

T. C. HOWDEN & Co.
5 & 7, Fleet Street,
BIRMINGHAM

Recently Published
GENERAL FOUNDRY PRACTICE

By A. M'William, A.R.S.M., D.Met., &
Percy Longmuir, D.Met., M.B.E.

Giving a condensed and crystallised account of the science and practice of iron, steel and brass founding. For designers metallurgists, foundry managers and foremen. Also of great value to moulders.

Fourth Edition. Revised Throughout and Enlarged by PERCY LONGMUIR, D.Met., Medium 8vo. Cloth. Pp. i-viii +457, with 2 Frontispieces and 303 illustrations.

Price 21s. Post 6d. Abroad 1s. 3d.

"One of the most practical books on foundry practice . . . thoughtful and valuable" — METALLURGIA

CHARLES GRIFFIN & CO., LTD. 42 Drury Lane,
LONDON, W.C.2

FOSECO PREPARATIONS

**Degas
ALUMINIUM
WITH
DEGASER No. I**

Effects:

Eliminates gases and pinholes ; finer grain ; cleaner surface ; increased Tensile and Elongation.

Simple, efficient, and inexpensive

FOUNDRY SERVICES LTD.
LONG ACRE, NECHELLS,
BIRMINGHAM, 7

FURNACE-HEAT AT 2·3d. PER THERM
THE "ROTAVAC" HEAVY OIL BURNER



- 1 Burns 200 sec. or waste oils without preheating and with remarkable efficiency.
- 2 Has exceptional atomising power, eliminating carbon deposit.
- 3 May be easily controlled by a single throttle regulator. This is made possible by the patented Unit Control system.
- 4 Eliminates danger of flooding.
- 5 Has a variable flame angle.
- 6 Jet dismantled by removing one locking nut.
- 7 Reduces your heating costs 10-25 per cent.

**NU-WAY HEATING
PLANTS, LTD.**
MacDonald Street,
BIRMINGHAM 5.

Telegrams: "JASNU." Telephone: Mid. 1507.

MARKET PRICES

ALUMINIUM.		GUN METAL.		SCRAP METAL.	
98 99% Purity.....	£100 0 0	*Admiralty Gunmetal Ingots (88 : 10 : 2)	£60 10 0	Copper Clean	£29 0 0
ANTIMONY.		*Commercial Ingots	44 0 0	" Braziery	26 0 0
English.....	£67 0 0	*Gunmetal Bars, Tank brand, 1 in. dia. and upwards. lb.	0 0 9	" Wire	—
Chinese.....	51 0 0	*Cored Bars	0 0 11	Brass	19 0 0
Crude	23 10 0	LEAD.		Gun Metal.....	28 0 0
BRASS.		Soft Foreign	£15 7 6	Zinc	9 0 0
Solid Drawn Tubes	lb. 9½d.	English	17 10 0	Aluminium Cuttings	74 0 0
Brazed Tubes	" 11½d.	MANUFACTURED IRON.		Lead	13 10 0
Rods Drawn	" 8½d.	Scotland—		Heavy Steel—	
Wire	" 7½d.	Crown Bars, Best	£10 5 0	S. Wales	3 5 0
*Extruded Brass Bars	" 4½d.	N.E. Coast—		Scotland	2 17 6
COPPER.		Rivets	10 10 0	Cleveland	2 17 6
Standard Cash	£36 12 0	Best Bars	10 2 6	Cast Iron—	
Electrolytic	40 15 0	Common Bars	9 5 0	Midlands	2 12 6
Best Selected	39 15 0	Lancashire—		S. Wales	2 17 6
Tough	39 5 0	Crown Bars	9 12 6	Cleveland	3 5 0
Sheets	68 0 0	Hoops.....	£10 10 0 to 12 0 0	Steel Turnings—	
Wire Bars	41 2 6	Crown Bars	9 12 6	Cleveland	2 0 0
Ingot Bars	41 2 6	Marked Bars.....	12 0 0	Midlands	2 0 0
Solid Drawn Tubes	lb. 10½d.	Unmarked Bars.....	from 7 5 0	Cast Iron Borings—	
Brazed Tubes	" 10½d.	Nut and Bolt		Cleveland	1 7 6
FERRO ALLOYS.		Bars	£8 10 0 to 9 0 0	Scotland	1 17 6
†Tungsten Metal Powder .. lb. 0 3 3		Gas Strip	10 12 6	SPELTER.	
†Ferro Tungsten	" 0 3 0	S. Yorks—		G.O.B. Official	—
Ferro Chrome, 60-70% Chr.		Best Bars	10 15 0	Hard.....	£11 5 0
Basis 60% Chr. 2-ton		Hoops	£10 10 0 to 12 0 0	English.....	14 5 0
lots or up.		PHOSPHOR BRONZE.		India	12 10 0
2-4% Carbon, scale 11/-		*Bars, " Tank " brand, 1 in. dia.		Re-melted	13 5 0
per unit	ton 29 15 0	and upwards—Solid	lb. 9d.	STEEL.	
4-6% Carbon, scale 7/-		*Cored Bars	11d.	Ship, Bridge, and Tank Plates	
per unit	" 22 7 6	†Strip	11d.	Scotland	£8 15 0
6-8% Carbon, scale 7/-		†Sheet to 10 W.G.	11½d.	North-East Coast	8 15 0
per unit	" 21 12 0	†Wire	1/0½	Midlands	8 17 6
8-10% Carbon, scale 7/-		†Rods	11½d.	Boiler Plates (Land), Scotland ..	8 10 0
per unit	" 21 12 0	†Tubes	1/1½	" " (Marine)	—
‡Ferro Chrome, Specially Re-		†Castings	1/0½	" " (Land), N.E. Coast ..	8 10 0
fined, broken in small		†10% Phos. Cop. £30 above B.S.		" " (Marine)	8 17 6
pieces for Crucible Steel-		†15% Phos. Cop. £35 above B.S.		Angles, Scotland	8 7 6
work. Quantities of 1 ton		†Phos. Tin (5%) £30 above English Ingots.		" North-East Coast	8 7 6
or over. Basis 60% Ch.		PIG IRON.		" Midlands	8 7 6
Guar. max. 2% Carbon,		Scotland—		Joists	8 15 0
scale 11/0 per unit ..	" 33 10 0	Hematite M/Nos.	£4 5 6	Heavy Rails	8 10 0
Guar. max. 1% Carbon,		Foundry No. 1	4 1 6	Fishplates	12 10 0
scale 12/6 per unit ..	" 36 5 0	No. 3	3 19 0	Light Rails	8 15 0
§ Guar. max. 0.7% Carbon,		N.E. Coast—		Sheffield—	
scale 12/6 per unit ..	" 37 5 0	Hematite No. 1	4 5 6	Siemens Acid Billets	9 2 6
‡ Manganese Metal 97-98%		Foundry No. 1	3 17 0	Hard Basic	£6 17 6 to 7 2 6
Mn.	lb. 0 1 2	Foundry No. 3	4 0 0	Medium Basic	£6 12 6 and 7 0 0
‡ Metallic Chromium	" 0 2 5	Northants—		Soft Basic	5 10 0
§ Ferro-Vanadium 25-50% ..	" 0 12 8	Foundry No. 1	4 3 0	Hoops	£9 10 0 to 9 15 0
§ Spiegel, 18-20%	ton 7 10 0	Forge	3 14 0	Manchester	
Ferro Silicon—		Silicon Iron	—	Hoops	£9 0 0 to 10 0 0
Basin 10% scale 3/-		Forge	3 14 0	Scotland, Sheets 24 B.G.	10 10 0
per unit	ton 6 5 0	Midlands—		HIGH SPEED TOOL STEEL.	
20/30% basis 25% scale		N. Staffs Forge No. 4	3 17 0	Finished Bars 14% Tungsten .. lb. 2/-	
3/6 per unit	" 9 0 0	Foundry No. 3	4 0 0	Finished Bars 18% Tungsten 2/9	
45/50% basis 45% scale		Northants—		Extras	
5/- per unit	" 12 5 0	Foundry No. 1	4 3 0	Round and Squares, ½ in. to ½ in. ..	3d.
70/80% basis 75% scale		Forge No. 4	3 14 6	Under ¼ in. to ⅛ in. ..	1/-
7/- per unit	" 17 17 6	Foundry No. 3	4 0 0	Round and Squares 3 in. ..	4d.
90/95% basis 90% scale		Derbyshire Forge	3 17 6	Flats under 1 in. x ¼ in. ..	3d.
10/- per unit	" 28 17 6	" Foundry No. 1	4 3 0	" " ¼ in. x ¼ in. ..	1/-
§ Silico Manganese 65/75%		West Coast Hematite	4 5 6	TIN.	
Mn., basis 65% Mn. ..	" 12 5 0	East	4 5 6	Standard Cash	£188 15 0
§ Ferro-Carbon Titanium,		SWEDISH CHARCOAL IRON		English	188 10 0
15/18% Ti	lb. 0 0 4½	AND STEEL.		Australian	—
Ferro Phosphorus, 20-25% ton 20 0 0		Pig Iron Kr. 108		Eastern	184 5 0
§ Ferro-Molybdenum, Molyte lb. 0 4 6		Billets Kr. 240-310 £12 7 6-£16 0 0		Tin Plates I.C. 20 x 14 box 18/9	
§ Calcium Molybdate	" 0 4 2	Wire Rods Kr. 290-340 £15 0 0-£17 10 0 0		ZINC.	
FUELS.		Rolled Bars (dead soft)		English Sheets	£24 0 0
Foundry Coke—		Kr. 200-220 £10 6 0-£11 7 0		Rods	26 0 0
S. Wales	— 1 10 0	Rolled Charcoal Iron Bars		Battery Plates	—
Scotland	— 1 10 0	Kr. 290 15 0 0		Boiler Plates	—
Durham	1 5 0 to 1 6 0	All per English ton. f.o.b. Gothenburg.			
Furnace Coke—		Converted at £1 = Kr. 19.40 approx.			
Scotland	— 1 5 0				
S. Wales	— 1 5 0				
Durham	— 1 2 6				

